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Section 111

Shoreline Stabilization Report and Draft Environmental Assessment

Virginia Key, Dade County, Florida

US Army Corps of Engineers

Jacksonville District
South Atlantic Division

SECTION 111
SHORELINE STABILIZATION REPORT
AND DRAFT ENVIRONMENTAL ASSESSMENT
VIRGINIA KEY, DADE COUNTY, FLORIDA

SYLLABUS

This report provides the results of feasibility studies conducted under the authority of Section 111 of the River and Harbor Act of 1968, as amended, to stabilize the shoreline in the vicinity of Virginia Key, Florida. Section 111 authorizes the study, design, and construction of work for prevention or mitigation of damages to both non-Federal public and privately owned shores to the extent that such damages can be directly identified and attributed to Federal navigation works located along the coastal and Great Lakes shorelines of the United States. Construction and maintenance of the Miami Harbor Federal navigation project has had an adverse impact on the shoreline at Virginia Key.

The study concentrated on modifications to stabilize the shoreline. The recommended plan consists of several features: (1) constructing 3 new timber groins, (2) removing and replacing 25 timber groins; (3) and placing approximately 8,000 cubic yards of material onto the beaches.

As provided by the Section 111 authority, the cost of work to correct the erosion attributable to the navigation project will be a Federal responsibility. The benefits consist of the stabilization of the shoreline at Virginia Key and the preservation of the historical Old County Park. The project modification has a total estimated initial construction cost of $1,462,900.

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INTRODUCTION

1. This report summarizes planning, engineering and design studies of Virginia Key to determine whether the Federal navigation project at Miami Harbor, Florida has caused adverse impacts, and to determine appropriate mitigation measures and the level of Federal interest in these measures. Sufficient engineering detail is presented in this report so that, after report approval, preparation of contract plans and specifications for the proposed project modifications may proceed.

STUDY AUTHORITY

2. The Section 905(b) Preliminary Assessment, which was conducted in response to a letter dated July 25, 2000 from U.S. House of Representatives' Carrie P. Meek, indicated that furthur detailed study was warranted to determine the applicability of mitigative measures at Virginia Key. This study was accomplished under authority provided by Section 111 of the River and Harbor Act of 1968, as amended by the Water Resources Development Acts (WRDA) of 1986 and 1999. Section 111 reads as follows:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damage attributable to Federal navigation works. The cost of implementing measures under this authority would be shared by non-Federal interests in the same proportion as the costs for the project causing the damage. The cost of operating and maintaining such projects shall be borne entirely by non-Federal interests. No such project shall be constructed without specific authorization by Congress if the estimated Federal first cost exceeds $5,000,000."

PURPOSE AND SCOPE

3. The purpose of this study is to determine the feasibility and Federal interest in construction of shoreline erosion measures on Virginia Key to mitigate for any adverse impacts caused by the construction operations and maintenance of the Miami Harbor Federal navigation project. This study is based on the results of on-site inspections, extensive interagency coordination and previous and current engineering and environmental analysis.

LOCATION

4. Virginia Key is a barrier island located in Biscayne Bay in Dade, County, Florida. Virginia Key is located south of Government Cut and north of Key Biscayne. (See Figure 1). Rickenbacker Causeway provides access to Virginia Key from the mainland.

PRIOR STUDIES, REPORTS AND EXISTING WATER PROJECTS

5. **Prior Studies and Reports.** The Jacksonville District has conducted three Federal studies and constructed six Federal projects in the vicinity of the study area, and are discussed in the following paragraphs.

STUDIES

6. **Coast of Florida Erosion and Storm Effects Study**. The study was authorized by Section 104 of PL 98-360, and by resolution passed by the Committee on Public Works and Transportation, US House of Representatives dated 8 August 1984. The study includes the entire Florida coastline consisting of five major coastal regions. The feasibility study has two specific purposes: a review of existing Federal shore protection projects to determine if modifications were warranted; and development of a comprehensive body of knowledge, information and data on coastal area changes and processes in Florida. The feasibility study was undertaken as a series of five regional feasibility reports. A Chief of Engineers report summarizing the review of the authorized Federal shore protection projects in Dade, Broward and Palm Beach Counties (Region III) was completed 27 December 1996, and included the shoreline of Virginia Key. The Chief's report is included in House Document 105-163/105/1. The Corps of Engineers only recommended one project modification, a new sand transfer plant at Lake Worth Inlet. The feasibility study for the remaining regions in Florida have not been funded for completion (Federal funds for this study were last appropriated in Fiscal Year 1996).

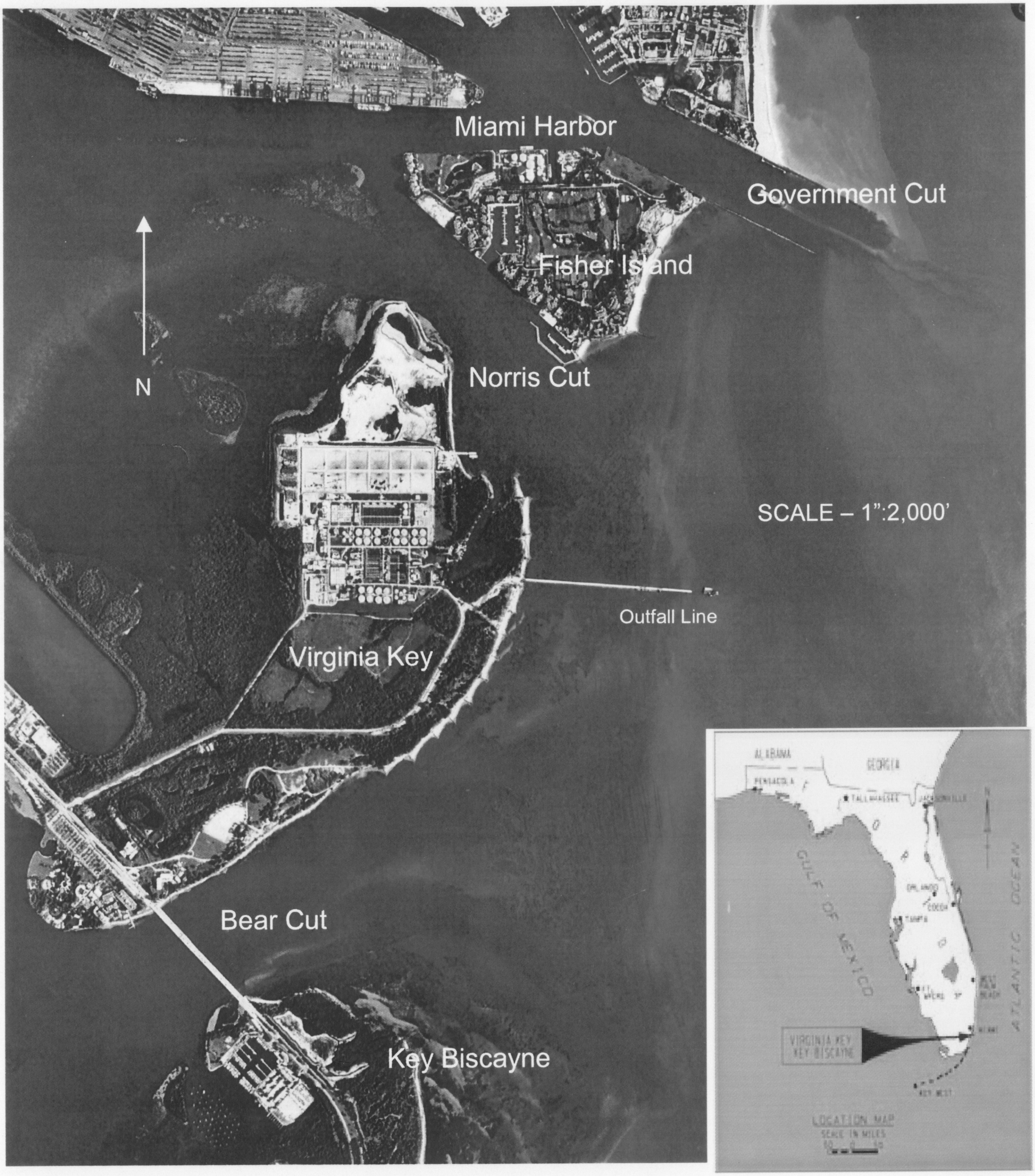


FIGURE 1: Study Area Map

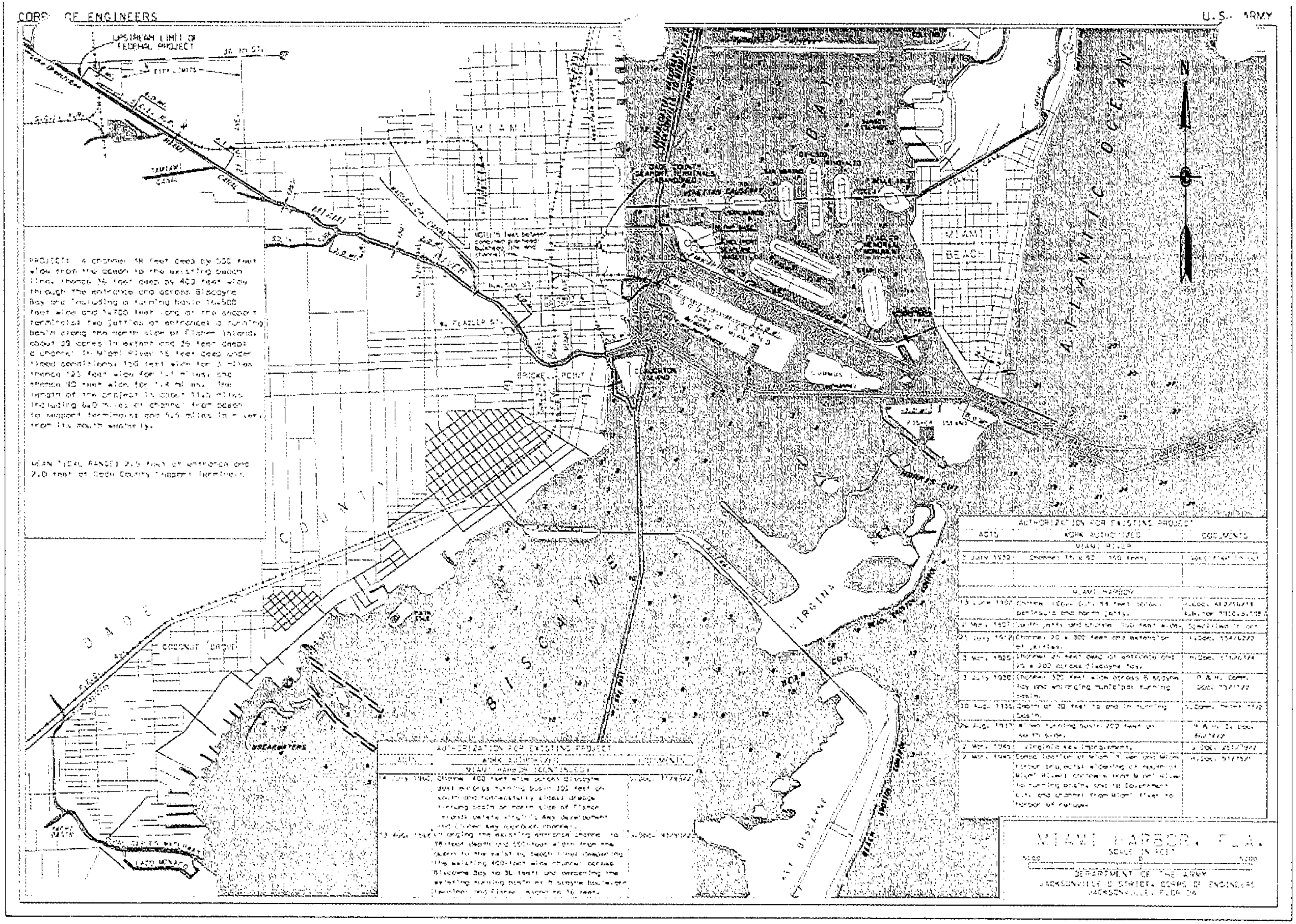


FIGURE 2: Miami Harbor Map.

7. **Watson Island Park, FL.** The Committee on Public Works, US House of Representatives on September 8, 1988 authorized a shore protection study of Watson Island. Watson Island is located at the western end of Miami Harbor, adjacent to the Intracoastal Waterway. The study has not been funded to date.

8. **Miami Harbor, FL.** The Committee on Transportation and Infrastructure of the US House of Representatives passed a resolution dated October 27, 1997 requesting a review of past reports to determine the feasibility of providing channel improvements in Miami Harbor and channels. This feasibility study has not been funded.

PROJECTS

9. **Miami Harbor, FL.** The current project was authorized by Section 101(a)(9) of the 1990 Water Resources Development Act (WRDA) and prior acts. The project is described in House Document 105-62/105/1. The project consists of 7.7 miles in the main ship channel. The authorized depths in the main ship channel are a depth of 44 feet and a width of 500 feet in the Bar channel and a depth of 42 feet and a width of 500 feet in Government Cut. The Miami River project segment consists of 5.8 miles in length to an authorized depth of 15 feet and widths varying from 90 to 150 feet. The project has 1.8 miles of connecting channels. The South Lummus Island Channel has an authorized depth of 42 feet and a width of 400 feet. Stone jetties north and south of Government Cut protect the main ship channel. The project also has a turning basin 1,700 feet long by 1,650 feet wide adjacent to Biscayne Boulevard. The project improvements are approximately 65 percent complete. The Federal and non-Federal implementation costs through Fiscal Year 1998 are $45.4 million and $24.3 million, respectively. The Federal operation and maintenance costs through Fiscal Year 1998 are $6.3 million. The 1997 traffic was 6.6 million tons.

10. Section 315 of WRDA 1999 authorized modifications to the Miami Harbor project. Section 315 provides authority to construct artificial reefs and related environmental mitigation required by Federal, state and local environmental permitting agencies for the project, if the Secretary (of the Army) determines that the project as modified is technically sound, environmentally acceptable, and economically justified.

11. **Intracoastal Waterway, Jacksonville to Miami.** The Intracoastal Waterway from Jacksonville to Miami, 349 miles in length, is a major segment of the Federal inland waterway system, which serves both commercial barges and recreational vessels. The Fort Pierce to Miami segment provides for a depth of 10 feet and a channel width of 125 feet. The US Army Corps of Engineers has maintenance responsibility of the waterway and side channels. The existing project was completed in 1965. Total project construction costs through Fiscal Year 1998 were $19,251,600 Federal and $61,000 non-Federal. Total Federal

project operation and maintenance costs through Fiscal Year 1998 were $51,858,100. The 1997 traffic was 424,000 tons.

12. **Dade County, FL**. The Federal hurricane and storm damage reduction project for Dade County, Florida was authorized by Section 501(a) of the 1986 Water Resources Development Act and prior acts. The project provides for restoration and periodic nourishment of 2.5 miles of shoreline at Sunny Isles and 1.2 miles of shoreline at Haulover Beach Park for storm damage reduction. The project provides for restoration and periodic nourishment of a hurricane and storm damage reduction project along 9.3 miles of shoreline from Bakers Haulover Inlet to Government Cut. The Sunny Isles, Haulover Beach Park and Bakers Haulover Inlet to Government Cut segments were initially restored in 1982, 1988 and 1982, respectively. Approximately 15.6 million cubic yards was initially placed for this project. Total project construction costs through Fiscal Year 1998 were $55.9 million Federal and $45.4 million non-Federal.

13. **Virginia Key, Key Biscayne, FL**. A Federal shore protection project for Virginia Key and Key Biscayne was authorized by the 1962 River and Harbor Act. The project is described in House Document 561/87/2. Approximately 1.8 miles of shore on Virginia Key and 1.9 miles of the northerly shore on Key Biscayne were restored in 1969 by placement of 410,000 cubic yards of sand. Dredging commenced on Jan. 9, 1969 and was completed on July 10, 1969. In 1972, 13 groins were constructed on Virginia Key to reduce sand losses. In 1974, 110,000 cubic yards were placed on Virginia Key in connection with the project deepening at Miami Harbor. Approximately $1,667,000 and $715,000 have been spent by the Federal and non-Federal project sponsor through Fiscal Year 1980, respectively. The Federal project was deauthorized in 1990 under the provisions of Section 1001(b)(1) of the 1986 Water Resources Development Act.

14. **Key Biscayne, FL**. The Chief of Engineers authorized a shore protection project for Key Biscayne in 1982 under the provisions of Section 103 of the 1962 Rivers and Harbor Act. The project provides for placement of 330,000 cubic yards of initial restoration and periodic nourishment of the southern 2.4 miles of Key Biscayne between the southern boundary of Crandon Park and the Cape Florida Lighthouse, and includes a terminal groin at the southern limit of the initial restoration. Project construction was completed in 1987 at a total cost of $2.4 million. The Federal share was limited to $1 million under the authority of Section 103. The project's terminal groin was rehabilitated following Hurricane Andrew in 1992 by replacement of 390 tons of armor stone and 280 tons of bedding stone under the authority of Public Law 84-99. This work was completed in 1994 at a cost of $84,000.

15. **Bill Baggs Cape Florida State Recreation Area, Key Biscayne, FL**. The Chief of Engineers authorized a shore protection project for Key Biscayne in 1967 under the provisions of Section 103 of the 1962 Rivers and Harbor Act.

The project provides for construction of a 283 foot-long stone revetment at Cape Florida Lighthouse, which is located at the southern end of Key Biscayne. Project construction was completed in 1968 at a total cost of $48,000. The revetment was rehabilitated following Hurricane Andrew in 1992 under the authority of Public Law 84-99. This work was completed in 1994 at a cost of $72,000.

PLAN FORMULATION

16. The Federal objective of water and related land resources planning is to contribute to national economic development consistent with protecting the Nation's environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements.

17. The Corps' planning process follows a six-step structure to solve problems in a rational framework providing for sound decision making. The six-step process is used by the Corps in all of its planning studies. The six steps are (1) identify problems and opportunities; (2) inventory and forecast conditions; (3) formulate alternative plans; (4) evaluate alternative plans; (5) compare alternative plans; and (6) select a plan.

18. **Problems and Opportunities**. Virginia Key is experiencing a number of problems which are attributable to the Federal navigation project at Miami Harbor. Construction and maintenance activities at Miami Harbor have eliminated southward littoral sediment which would otherwise be transported the beaches on the southern end of Virginia Key. The two jetties constructed at Government Cut have served as an almost complete littoral barrier to the downdrift beaches. As a result of this lack of littorally transported material, the beaches at Virginia Key have experienced continued erosion and require stabilization.

19. **Historic Conditions.** The island of Virginia Key encompasses approximately 2.55 miles of shoreline facing the Atlantic Ocean and has approximately 1,000 acres of land area. The island contains marine stadium basin properties, an old landfill, beach and hammock areas, a shrimpers lagoon and wastewater treatment plant, critical wildlife areas and adjacent environmental lands, the north point beach area and the old county park site.

20. On the 2,100-ft long shoreline at the "Old County Park", a total of 27 timber groins were constructed by local interests. Some of the timber groins were constructed in 1948, and the rest in 1956. The groins were approximately 50 feet long and spaced 50 to 150 feet apart (See Figure 3). In 1965, Dade County installed or extended 10 groins. The new groins were placed along 1,100 ft of shoreline on the southern portion of Virginia Key. These new groins were concrete pilings with adjustable horizontal boards.

21. The Old County Park is of significant historical value to the African-American community in Miami. During the early to mid 1900's, the park was the only beach that African-Americans were allowed to use in Dade County. The park included, among other facets, the Virginia Beach where the timber groins were constructed along the shoreline for the protection of the beach.

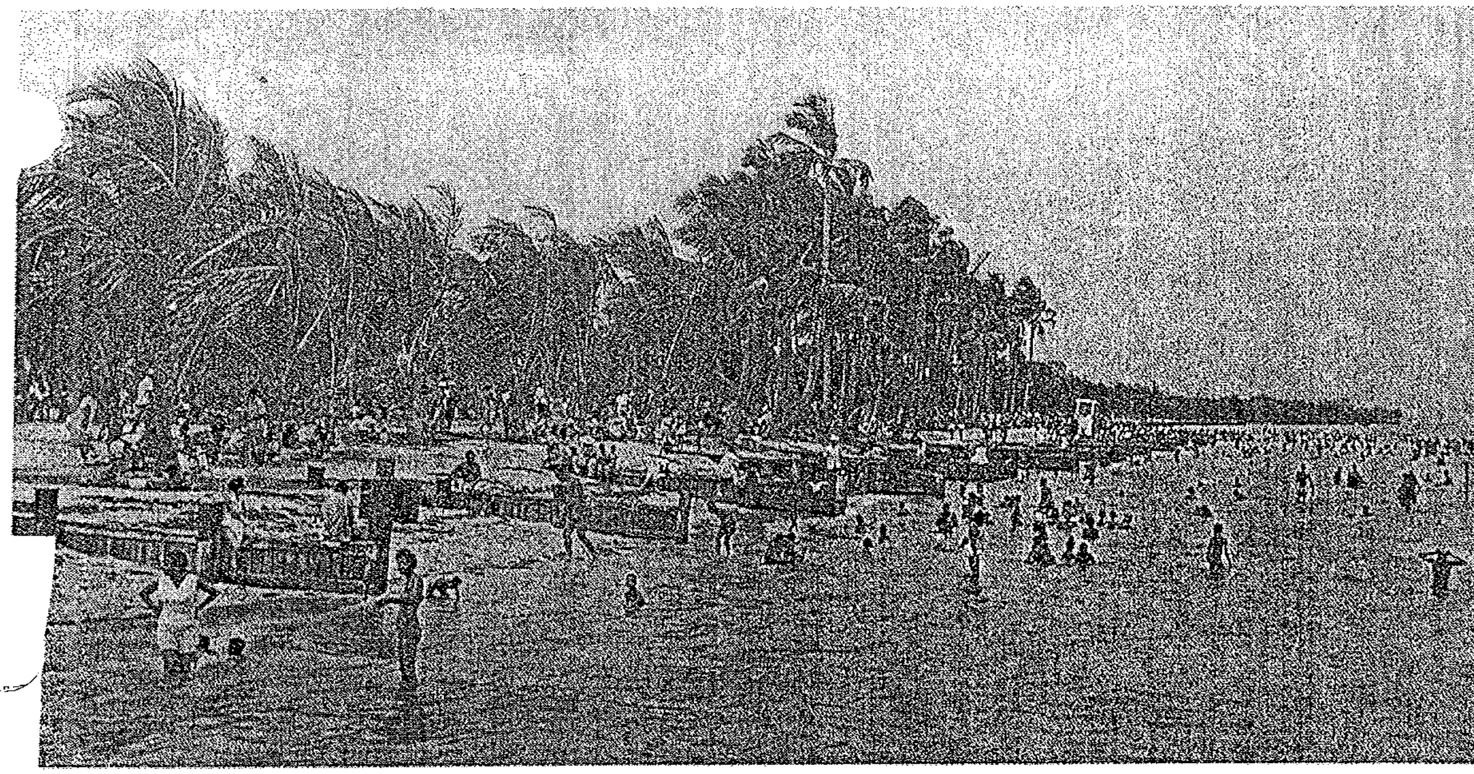


FIGURE 3. Historical Timber Groins (1960s).

22. In 1969, in an attempt to stabilize and maintain the beaches at Virgnia Key and Key Biscayne, the Corps completed a beach erosion control project. The authorized project provided for initial restoration with periodic nourishment to the shorelines at Virginia Key and Key Biscayne and authority for the construction of four groins. Approximately 180,000 cubic yards of fill material was placed on the beaches at Virginia Key and 120,000 cubic yards of material was placed at Key Biscayne in 1969. Although considered, the groins were not constructed at that time.

23. Due to the severe erosion experienced on Virginia Key, after the 1969 placement of fill, the Corps in 1972 constructed one impermeable groin and twelve permeable groins at the northerly limit of the project. The groins are approximately 330 ft long and spaced 500 ft apart (See Figure 4). In 1974, approximately 100,000 cubic yards of material was placed on the beach within the limits of the 13 groins. The Federal project for Virginia Key and Key Biscayne was deauthorized in 1990.

FIGURE 4. Federally Constructed Groins (June 1993)

24. **Existing Conditions**. The former Virginia Key beach area, at the Old County Park (77-acres), remains closed to public use except for special events. A severe to moderate eroding beach shoreline, dangerous nearshore currents and a lack of park staff to supervise the area, has necessitated the closure. Based on Corps inspections, 24 of the originally constructed 27 timber groins located at the southeastern end of the island, are in various stages of disrepair (See Figure 5). This timber groin system, though appearing to be somewhat functional based on sand accumulation between the groins, is deteriorated and in need of rehabilitation. The beach area, located south of the last rock groin of the deauthorized Federal Shore Protection project and immediately north of the first timber groin, is also severly eroded (Figures 6 and 7).

FIGURE 5. Existing Timber Groins(Dec. 2000)

FIGURE 6. Eroded Area (Looking North) (Dec 2000).

FIGURE 7. Eroded Area (Looking North) (Dec 2000).

25. **Future Without Project Conditions.** Because of its historical nature, the stabilization of the shoreline at Virginia Key is of significant concern. There is evidence that very little material bypasses the rock groin field to the north of the Old County Park, and waves and tidal currents continually transport material westward out of the park area with little natural replenishment. The timber groin field has deteriorated to such an extent that it is completely ineffective at low tide levels, and only marginally effective at higher tide levels. If no constructive measures are taken, the shoreline will continue to erode and the groins will furthur deteriorate.

NATURAL FORCES

26. Winds and Waves. The predominant wave source influencing navigation in the study area is wind generated. During the months of September through February, wind generated waves predominantly approach from the northeast to east and have an average height of 1.8 ft. During March, April, and May, the waves predominantly approach from the east and have an average height of 1.6 ft. During the months of June through August, waves predominantly approach from the east to southeast with an average height of 1.3 ft. The waves approaching from the northeast to the south occur approximately 78 percent of the time. During the remaining 22 percent of the time, waves generally less than 1.0 ft in height approach Virginia Key from Key Biscayne and impact the bayside beach. A more detailed summary of the winds and waves affecting the study area is located in the Engineering Appendix (Appendix A).

27. Tides. The tide in the study area is "semi-diurnal" with a mean tide range and spring tide range of 2.05 ft and 2.46 ft, respectively. Additional information on the astronomical tides and storm surge is included in the Engineering Appendix (Appendix A).

28. Currents. Current flow through Bear Cut is driven primarily by the astronomical tides. The current directions and velocities therefore fluctuate, with two flood (incoming) and two ebb (outgoing) tides during each 24-hour period. No tidal velocities have been published for the Bear Cut channel, but tidal velocities at other nearby inlets published by NOAA [reference (n)] indicate that velocities of 2-3 knots (3.4 – 5.1 ft/sec) occur during each tidal cycle. The highest tidal current velocities are observed in the channel which runs through the center of the inlet. During a field inspection of the project area in December 2000, tidal currents on the order of 3-5 knots were observed well offshore of the project shoreline in the channel, but velocities along the shoreline were almost zero. Additional information on currents, including the results of hydrodynamic numerical modeling is included in the Engineering Appendix (Appendix A).

29. Storms. The hurricane season, in general, extends from June to late October. However, tropical disturbances have affected Florida as early as March and as late as December. Hurricanes that form in the months of June and July

are spawned entirely on the western side of the Atlantic in the lower latitudes and in the western Caribbean. They are inclined to be weak and seldom present any great threat to coastal areas. Amore detailed summary if storm events affecting the study area is included in the Engineering Appendix (Appendix A).

Miami Harbor Shoreline Impact Analysis

30. The Jacksonville District performed a coastal engineering analysis of the impacts of the improvements to Miami Harbor in October 1988. The analysis was published in House Document 101-205, Miami Harbor Channel, Florida, dated June 1990. This analysis is attached to this report in the Engineering Appendix (Appendix A). The main conclusions from this analysis are stated below:

> *"Surveys available from 1851 to 1960, which span the four decades before and after the period that Government Cut was constructed (1903 to 1924), clearly indicate that most of the shoreline changes caused by the project occurred before the 1926 hurricane. Surveys in 1919 and 1927 encapsulate the effects of this hurricane on the shorelines both north and south of Government Cut and remove the results of this episodic event from the analysis of the effects of the navigation project of the adjacent shorelines. Surveys taken after the 1926 hurricane, and shoaling records for the entrance channel at Government Cut, show that the major shoreline changes resulting from the navigation project had tapered off by about 1930 and that the continuing erosion on Virginia Key had reduced by an order-of-magnitude. The rate of shoreline recession on Virginia Key increased in the late 1950's due to nearby dredge and fill operations, but not to the rates recorded prior to 1930.*
>
> *The beaches north and south of the Miami Harbor navigation project have been rebuilt as part of the Federal shore protection program during the 1970's and 80's. The small amount of littoral (material) that no longer drifts south past the jetties at Government Cut to nourish Virginia Key and Key Biscayne (estimated to be 10,000 to 15,000 cubic yards per year) is insignificant when compared to the quantities placed on these islands under this (shore protection) program. It is concluded that further improvements to Miami Harbor, within the confines of the existing project at Government (Cut), will have no impact, positive or negative, on the adjacent shorelines."*

31. The conclusions were based on survey data from 1851 to 1960, and anecdotal information regarding the construction and performance of the Virginia Key/Key Biscayne shore protection project in the late 1960s to early 1970s. This previous analysis, and new coastal engineering analysis for the period 1960 through 2000 will be examined. The mean high water shoreline change and volume change tables for the period 1851 to 1960 are included herein for

comparison to similar information for the 1960 to 2000 period. Storm impacts, sediment budget, sea level rise and the performance of the Virginia Key project will be discussed.

Historical Shoreline Changes

32. The mean high water data for the period 1851 to 1960 is shown in Table 1. The basis for the data are surveys made by the US Coast and Geodetic Survey in 1851, 1867, 1913, 1919, 1927, 1935 and 1945-47, and by the US Army Corps of Engineers in 1960. The data, reproduced from D. O. File 24-27, 094-3, is shown in Figure 8. This figure also shows the location of profile lines 4 through 9, which were taken as part of the cooperative study and report for Virginia Key and Key Biscayne (USACE, 1961). The mean high water lines at the intersection of these profile lines produces the data in Table 1.

Table 1: Mean Highwater Shoreline Changes (1851-1960)* (ft)

	1851 to 1919		1919 to 1927		1927 to 1935		1935 to 1945-47		1945-47 to 1960	
Profile	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession
4		-260		-90	70			-180	70	
5		-750		-120	80		No Change		90	
6		-1,000		-200		-300		-60	100	
7		-120		-100		-230		-40	80	
8		-20		-100		-40		-60	60	
9				-80	30		No Change		No Change	

* From Table B-1, page B-2 of the Beach Erosion Control Report on 'Cooperative Study of Virginia Key and Key Biscayne, Florida, US Army Engineer District, Jacksonville, FL, September 29, 1961

33. The surveys of 1851 and 1867, covering a period of 16 years, indicated that Virginia Key' shoreline was relatively stable. Construction of the north jetty at Government Cut began in 1904. Dredging began in 1907. The earliest survey of 1851 compared to the 1919 survey includes the effects of harbor construction. Virginia Key receded, which averaged 430 ft for this period. The shoreline receded an average of 115 ft from 1919 to 1927. Profiles 6, 7 and 8 receded an average of 190 ft, and profiles 4,5 and 9 showed advance for the period 1927 to 1935. The shoreline receded an average of 57 ft for the period 1935 to 1945-47. From 1945-47 to 1960, the shoreline advanced an average of 67 ft. Overall from 1851 to 1960, the shoreline for profiles 4, 5 and 6 receded an average of 750 ft, while profile lines 7, 8 and 9 receded an average of 117 ft.

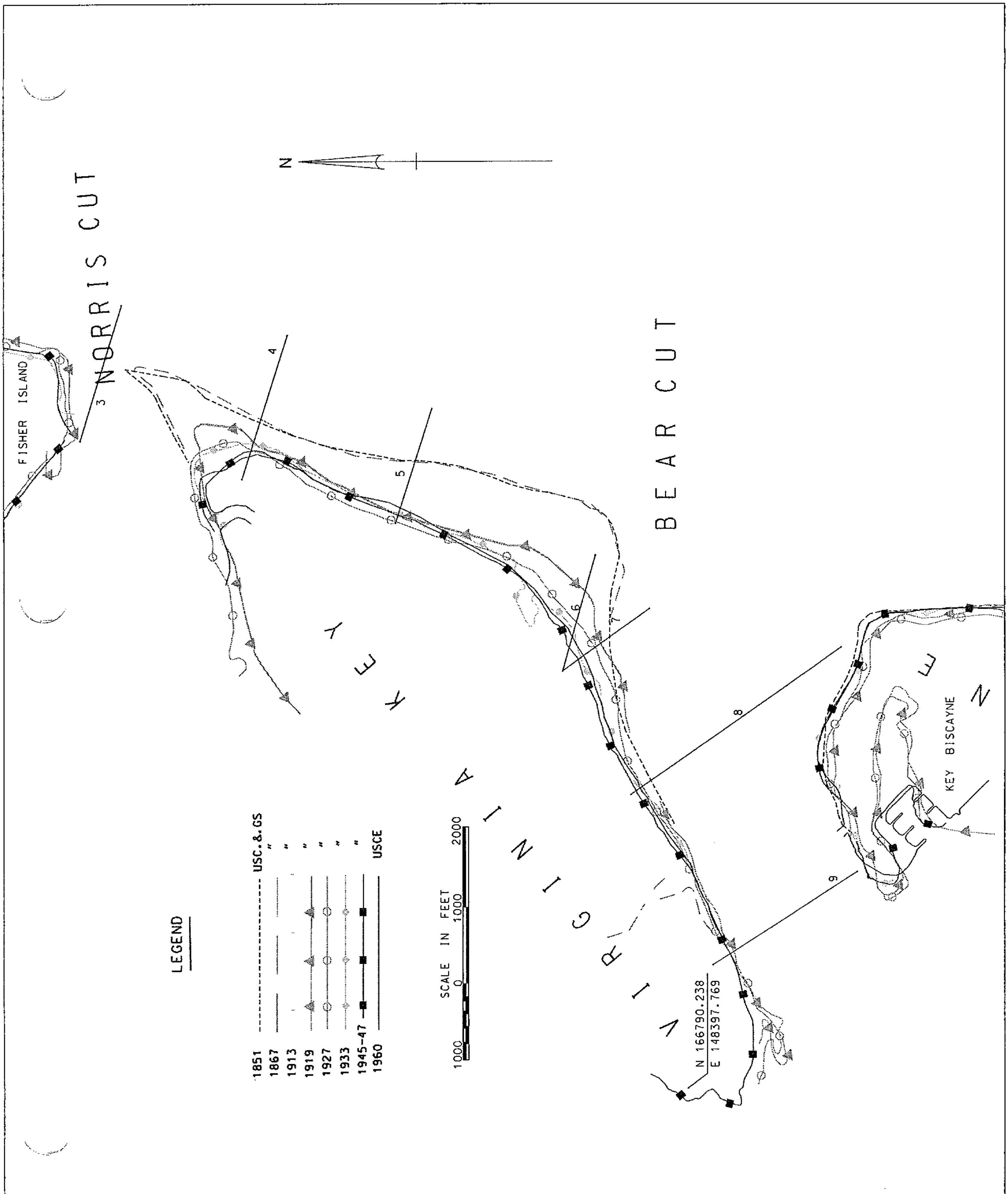


FIGURE 8. SHORELINE AND OFFSHORE DEPTH CHANGES (1851-1960)

34. Table 2 shows mean high water shoreline changes at Virginia Key for the period 1960 through 2000. The mean high water data for 1977, 1981, 1992 and 2000 are interpolated mean high water lines taken from vertical aerial photography. Controlled aerial photography of the area was flown September 1, 1999 (MH 99-173 R1 2-15, 1:24,000) is shown as Figure 1. The vertical uncontrolled aerial photography flown on April 22, 1977 (VKBE 2-5 to 2-15, 1:3600), March 6, 1981, and January 11, 1992 (91-422 CFDC R-1 4-21 to 4-25, 1:7200) were scanned into digital images, then ortho-rectified into a mosaic image to the same scale as the 2000 images (Virginia Key Shoreline Survey No. 01-217). The resulting aerial mosaic images for 1977, 1981 and 1992 are shown as Figures 9, 10 and 11, respectively. The continuous mean high water line was then estimated for each set of images. Transects for profile lines 4 through 9 were then used to measure distance differenced between the mean high water data. Additional transects 4A, 5A, 7A and 8A were added for this analysis. The locations of all the profile line transects are shown in Figure 12. The measured changes in mean high water at the transect lines are shown in Table 2.

Table 2: Mean High Water Shoreline Changes at Virginia Key (1960-2000) (ft)

	1960 to 1977		1977 to 1981		1981 to 1992		1992 to 2000		1960 to 1999		
Profile	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Advance	Recession	Total
4		(-488)	49			-20		-9	49	-29	20
4A	3			-4		-4		-4.3	3	-12.3	-9.3
5		-7	31			-64	15		46	-71	-25
5A		-133	113			-104		10	113	-227	-114
6		-149	66			-285		-56	66	-490	-424
7			3			-54		-32	3	-86	-83
7A	10			-34		-82	14		24	-116	-92
8	96			-51		-99	24		120	-150	-30
8A	41		56			-53	4		101	-53	48
9	110			-4		-25	35		145	-29	116

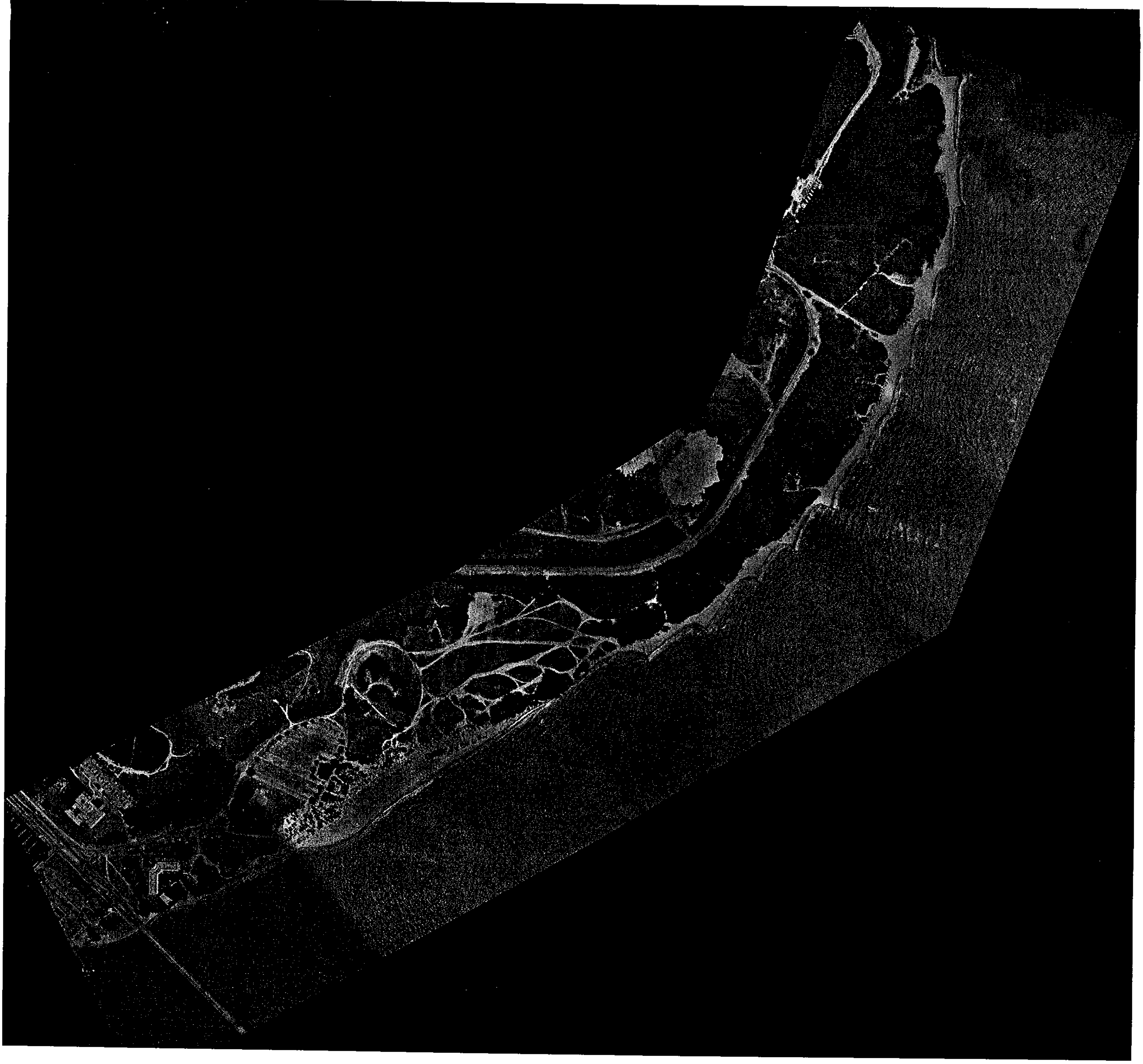


FIGURE 9: AERIAL MOSAIC IMAGES OF VIRGINIA KEY (1977)

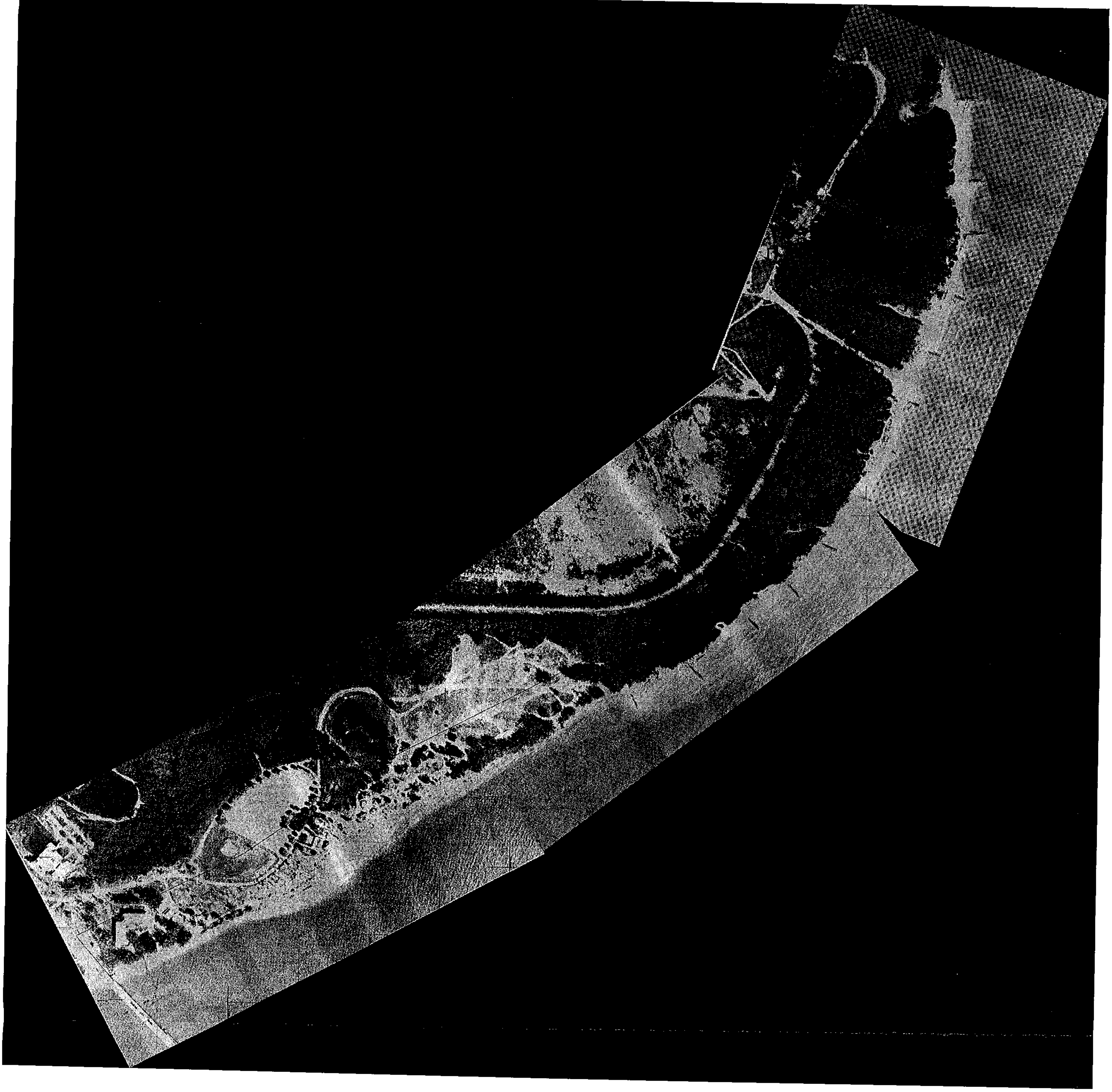


FIGURE 10: AERIAL MOSAIC IMAGES OF VIRGINIA KEY (1981)

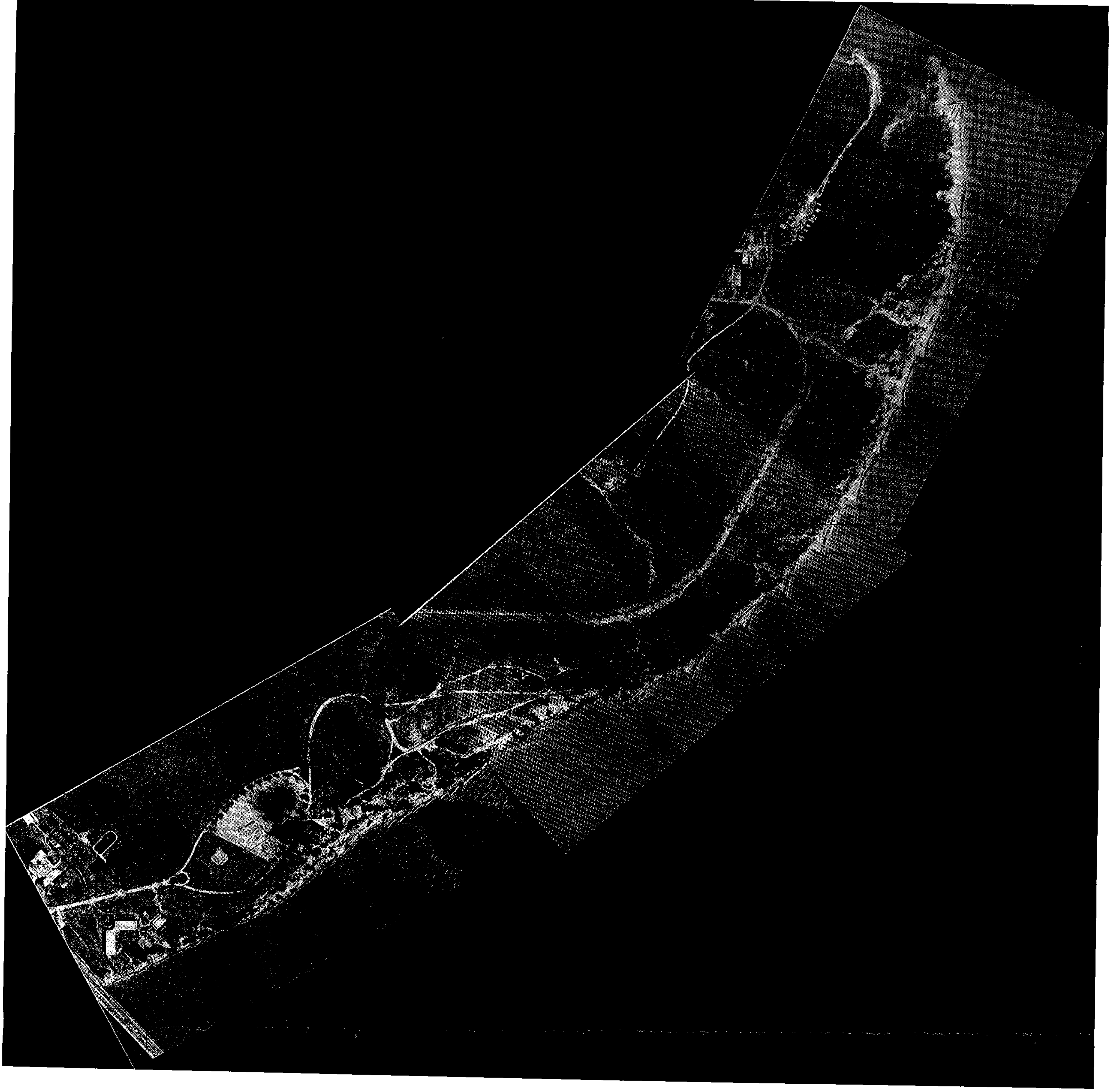


FIGURE 11: AERIAL MOSAIC IMAGES OF VIRGINIA KEY (1992)

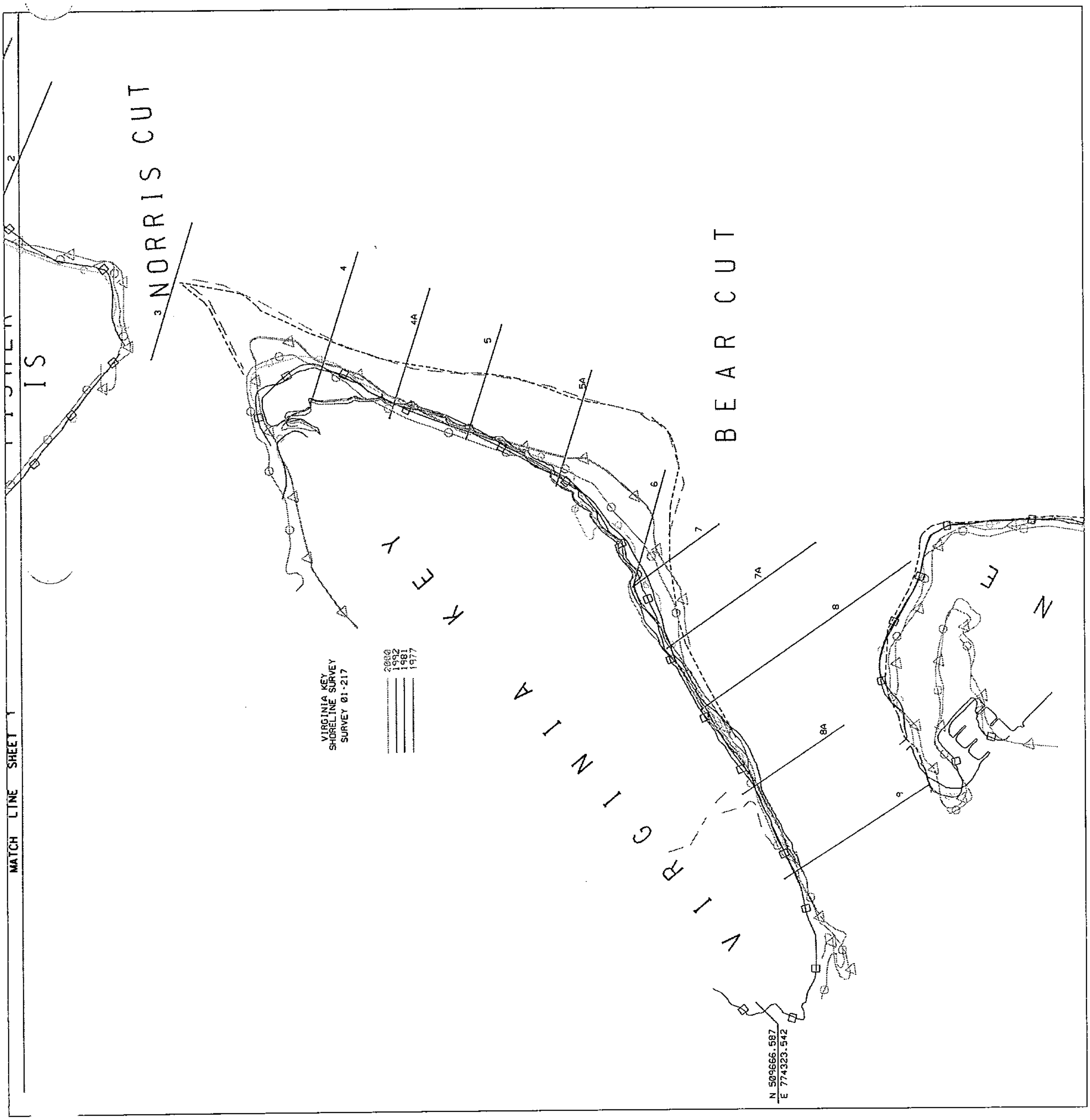


FIGURE 12: SHORELINE AND OFFSHORE DEPTH CHANGES (1977-2000)

35. The mean high water changes for the period 1960 to 1977 reflect the movement of the Virginia Key project fill southward, as evidenced by the 64 ft average shoreline advance for profiles 7a, 8, 8A and 9. The fill came from the project in the area of profile lines 5, 5A and 6, which receded an average of 96 ft for the period. Evidence of this can be seen in Figures 13 and 14. For the period 1977 to 1981, the shoreline advanced except for an erosion area at profiles 7A and 8. All of Virginia Key's shoreline receded and average of 79 ft for the period 1981 to 1992.

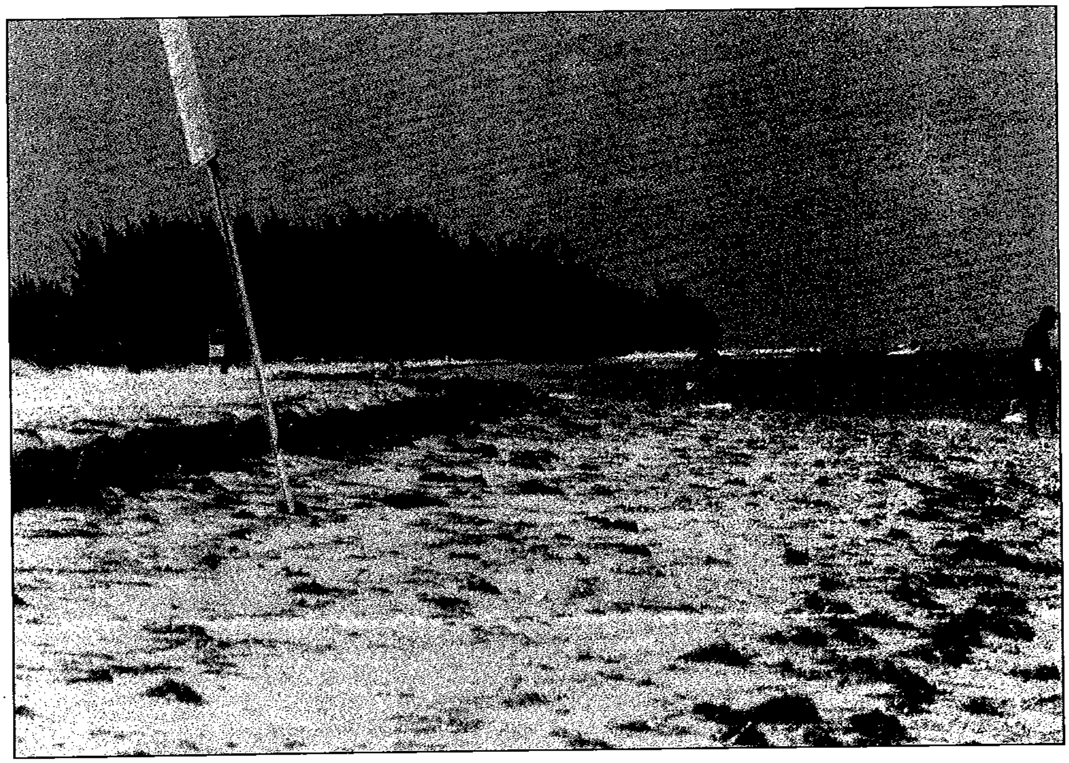


FIGURE 14: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (AUG 8, 1977)

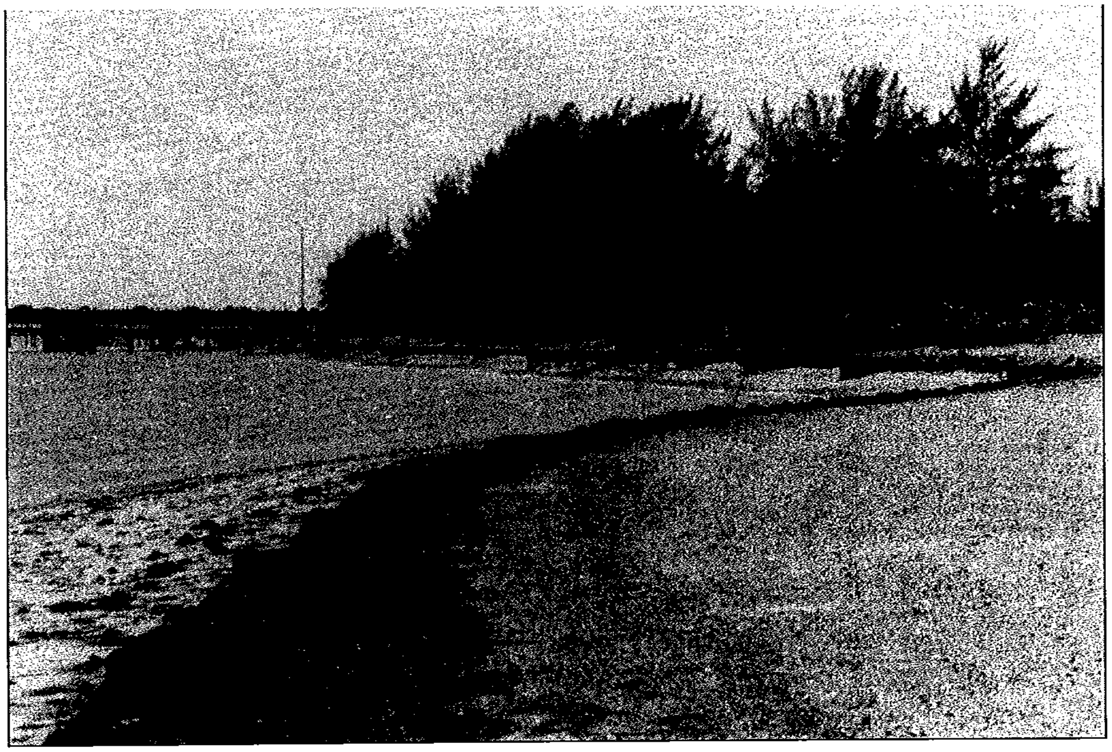


FIGURE 15: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (AUG 8, 1977)

36. For the period 1960 to 2000, profile lines 4A through 8 receded an average of 111 ft. The data for profile line 4 for the period 1960 to 1977 was discounted as being inconsistent with the combined 1969 and 1974 placement of 290,000 cubic yards.

Volumetric Changes

37. Based on the 1919 and 1960 survey data, Virginia Key eroded at a loss rate of 35,000 cubic yards per year (Shown in Table 3). Based on the 1927 and 1960 survey data, the total erosion measured along Virginia Key during this 33-year period was a loss of 540,000 cubic yards, or an average annual rate of 16,000 cubic yards per year. The rapid loss of the 1969 beach fill suggests a much higher rate of erosion, on the order of 70,000 cubic yards per year. The historical rate is based on erosion of the natural shoreline. This natural shoreline included large rocks and layers of stiff clay, which are visible today along the eastern reaches of the island. These materials erode much more slowly the beach quality sand.

Table 3: Volumetric Accretion and Erosion (1919-1960)

Reach	Net Change					
	Inner End of Profile		Outer End of Profile		Entire Length of Profile	
	1919 to 1960	Average Annual	1919 to 1960	Average Annual	1919 to 1960	Average Annual
From point 800 feet north of profile 4 to profile 4	-47	-1.1	19	0.5	-28	-0.7
4 to 5	-150	-3.7	-8	-0.2	-158	-3.9
5 to 6	-484	-11.8	-705	-17.2	-1189	-29.0
6 to 7	-25	-0.6	-584	-14.2	-609	-14.9
7 to 8	-283	-6.9	-360	-8.8	-643	-15.7
8 to 9	-206	-5.0	-406	-9.9	-612	-14.9
9 to point 1,7000 feet west of profle 9	-254	-6.2	-331	-8.1	-585	-14.3
Totals	-1,449	-35.3	-2,375	-57.9	-3,824	-93.3
Average Change	-207		-339		-546	

*From Table B-3, page B-7 of the Beach Erosion Control Report on 'Cooperative Study of Virginia Key and Key Biscayne, Florida, US Army Engineer District, Jacksonville, FL, September 29, 1961

Sea Level Rise

38. Based on previously published analysis for the Miami area (USACE, July 1996, Coast of Florida Study, Appendix A), the total relative sea level rise by the year 2046 would be .78 ft based on the historic trend, or 0.4 ft by 2020, with a one percent chance that the relative sea level rise by 2020 will exceed 0.8 ft. This translates to a possible shoreline recession rate of Dade County's ocean beaches of 0.93 ft per year. This estimate is for long straight sandy beaches having an uninterrupted supply of littoral material. Virginia Key's beaches are not long and straight, nor is there an adequate supply of littoral material, therefore applying any sea level rise-induced recession rate to Virginia Key's shoreline would be speculative.

Virginia Key/Key Biscayne, FL Project Performance

39. The 1962 River and Harbor Act (Public Law 87-874) authorized the Virginia Key/Key Biscayne shore protection project. The authorized project provided for Federal contribution of 70 percent of the cost of restoration and periodic nourishment of 1.8 miles on Virginia Key and 1.9 miles of beach on Key Biscayne for an initial period of 10 years. The project for Virginia Key started at profile 4

and extended southward to a point 400 ft north of Bear Cut Bridge. The 160,000 cubic yards for Virginia Key and 130,000 cubic yards for Key Biscayne's initial restoration was estimated to provide for two years periodic nourishment. The project authorization included 70 percent Federal participation in the cost of construction of three groins on Virginia Key and one groin on Key Biscayne, construction of which was subject to future determination of their need.

40. A contract was awarded on November 20, 1968 for placing 180,000 cubic yards of fill at Virginia Key and 120,000 cubic yards of fill at Key Biscayne at a total cost of $403,953 Federal, $192,168 non-Federal. Dredging commenced on January 9, 1969. The required beach material for Virginia Key was trucked to that site from sand stockpiled at the northern end of Key Biscayne. The fill placement length was reduced from 1.8 miles to 1.5 miles (the south limit of the project was moved from a point 400 ft north of Bear Cut Bridge to a point 2,000 ft north of the bridge) in order to avoid several seawater intakes located in the vicinity of the bridge. Construction was completed and accepted by the Government on July 10, 1969. A 1969 aerial photograph of the completed work on Virginia Key is shown in Figure 15.

FIGURE 15: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (1969)

41. The project fill at Virginia Key started eroding at an excessive rate almost immediately after construction, necessitating implementation of the authorized, but not constructed, groins. By early 1972 the 180,000 cubic yards of fill material was essentially lost from the placement area, indicating an annual loss rate of 70,000 cubic yards. Some of the material moved rapidly into Bear Cut. The remainder of the material moved southward and into the existing wooden groin field. Evidence of this can be seen in Figure 16 taken October 2, 1971. Since the existing groin field appeared to be successful, the design of the new groins at the north end of Virginia Key was patterned in part based on that design.

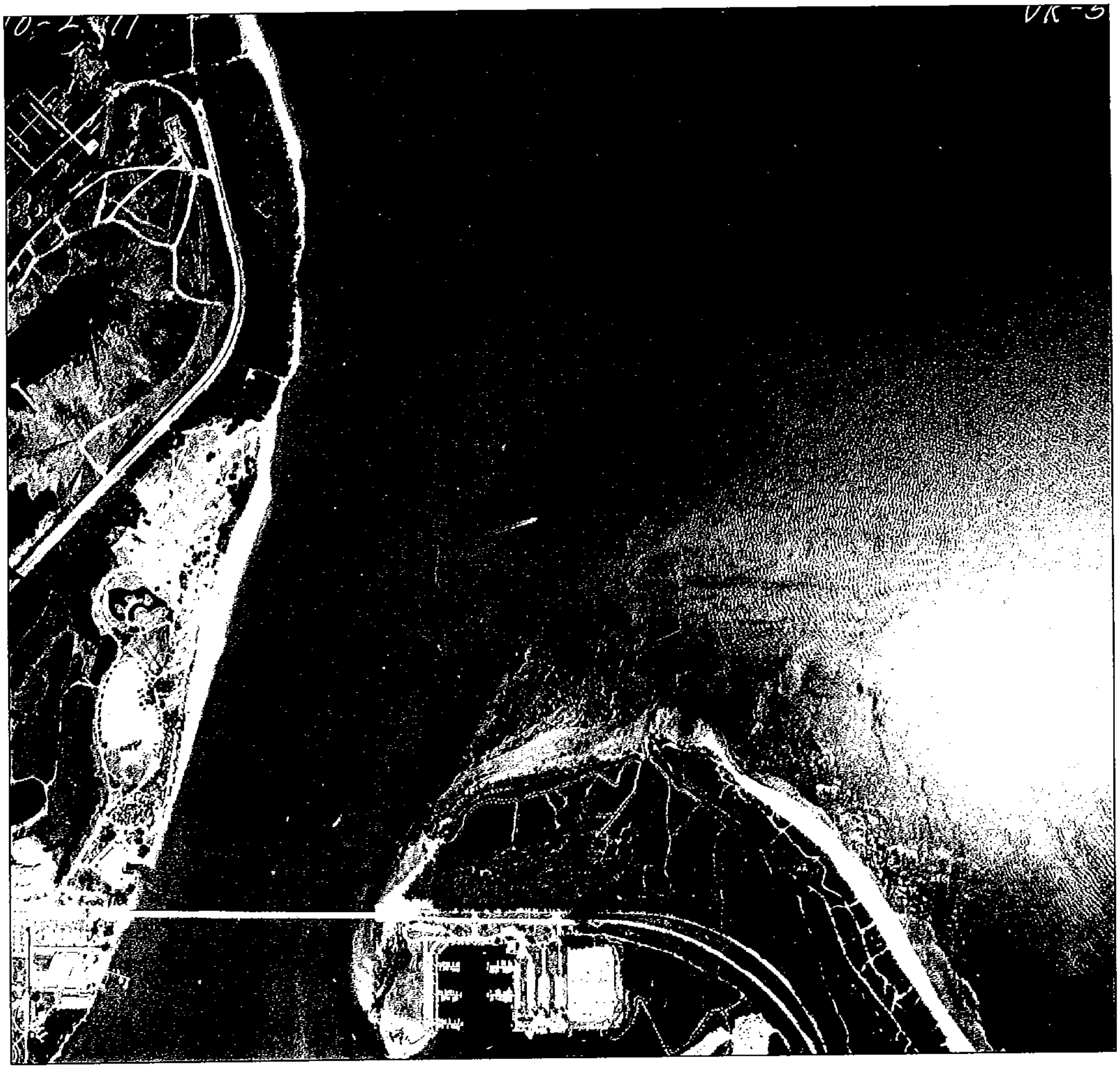


FIGURE 16: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (OCT. 2,1971)

42. In 1972, construction of 13 rubble mound groins was initiated. The condition of the groin construction in August 1973 can be seen in Figures 17 and 18. In 1974, approximately 110,000 cubic yards was placed in between the groins. The work was included in the contract for dredging Miami Harbor entrance channel and turning basin. Work for Virginia key commenced March 20, 1973. The work was completed in 1974 at a contract cost of $1,099,522. Figures 19 and 20 show the fill placement underway, and shortly after completion. Figures 21 and 22 show additional after completion aerials. The groin field was designed to reduce the annual loss rate from 70,000 to 35,000 cubic yards annually. Based on aerial photography shown as Figures 23 and 24, and Figures 13 and 14, there was an initial rapid loss of perhaps as much as 75 percent of the 110,000 cubic yards of Miami Harbor material placed in 1974 from the groin field, but by 1981, the fill between the groins had stabilized with little or no loss of material since then, as shown in Figures 25 through 27. This is confirmed by surveys taken in 1992 as compared to the as-built beach profile sections for the project fill, as shown in Figure 28.

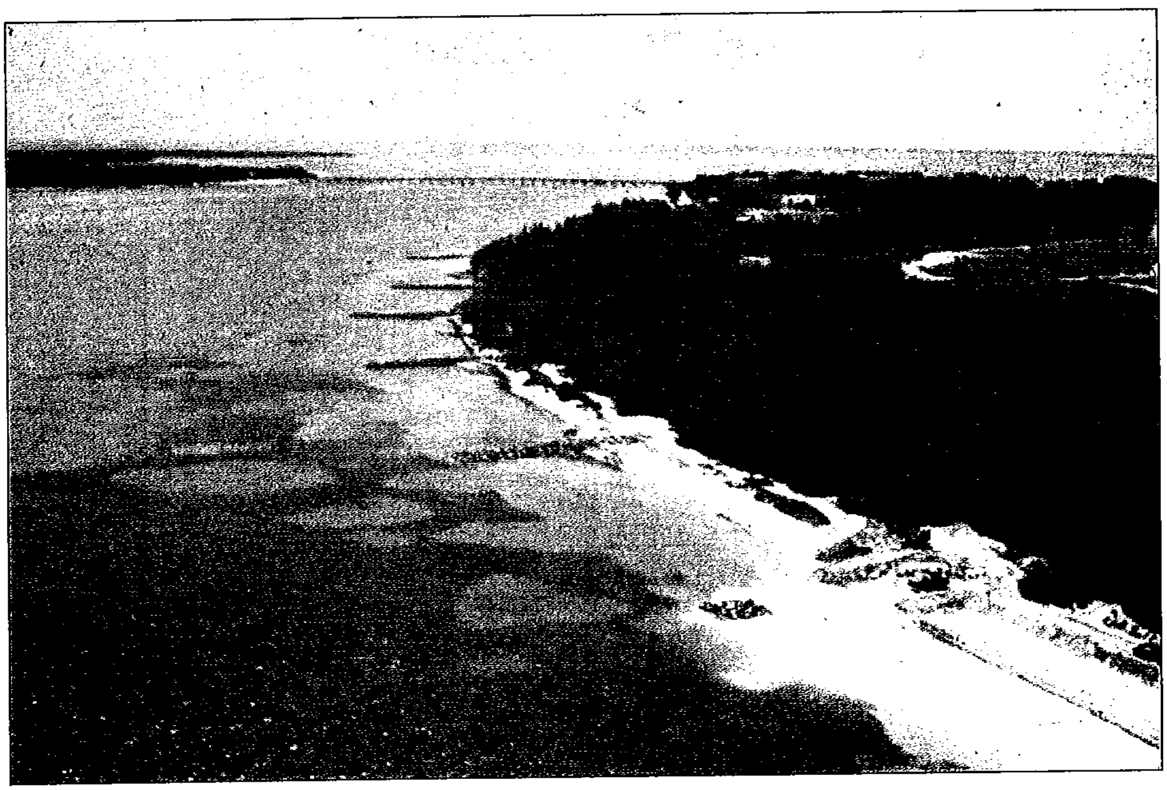


FIGURE 17: VIRGINIA KEY PHOTO - GROINS UNDER CONSTRUCTION -, (AUG 1973)

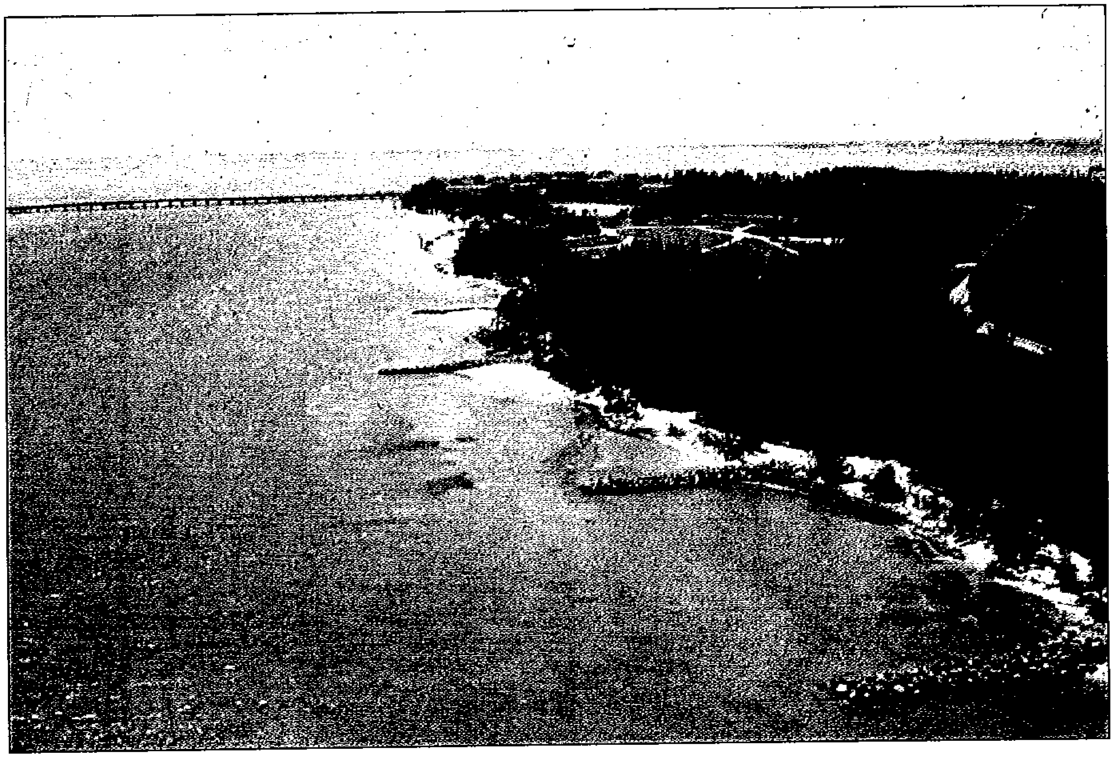


FIGURE 18: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE, (AUG 1973)

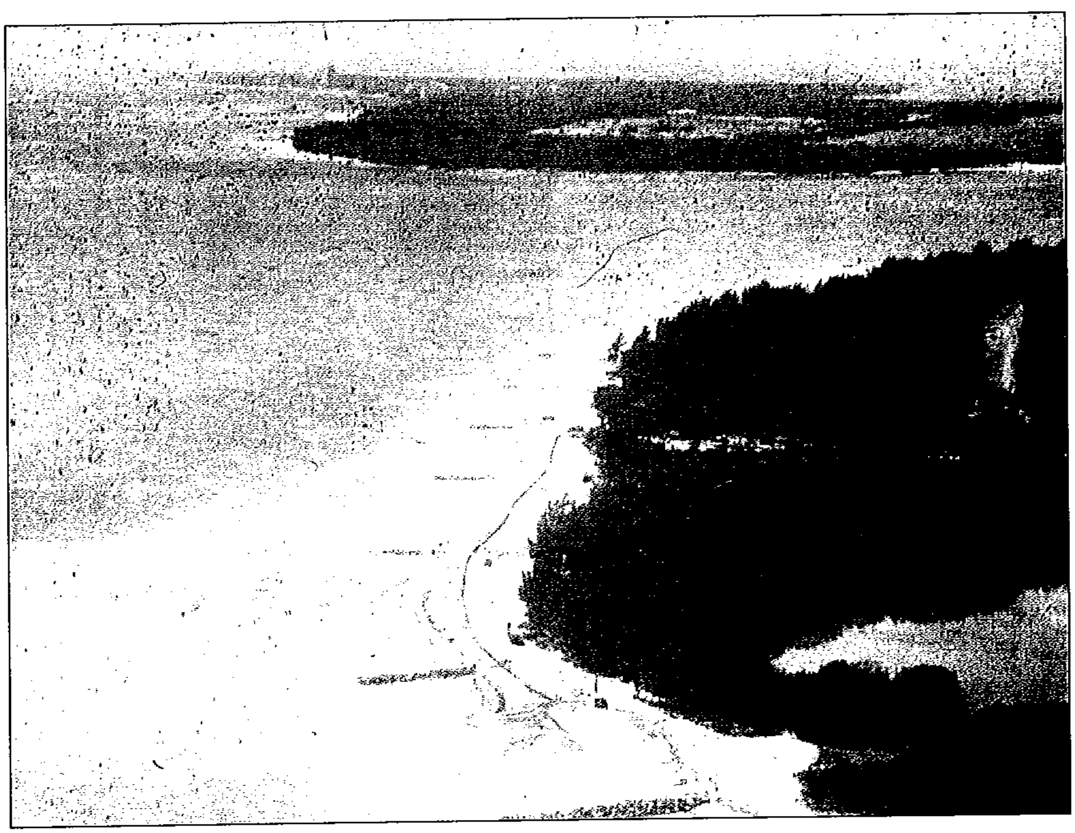


FIGURE 19: VIRGINIA KEY PHOTO - DURING CONSTRUCTION (1974)

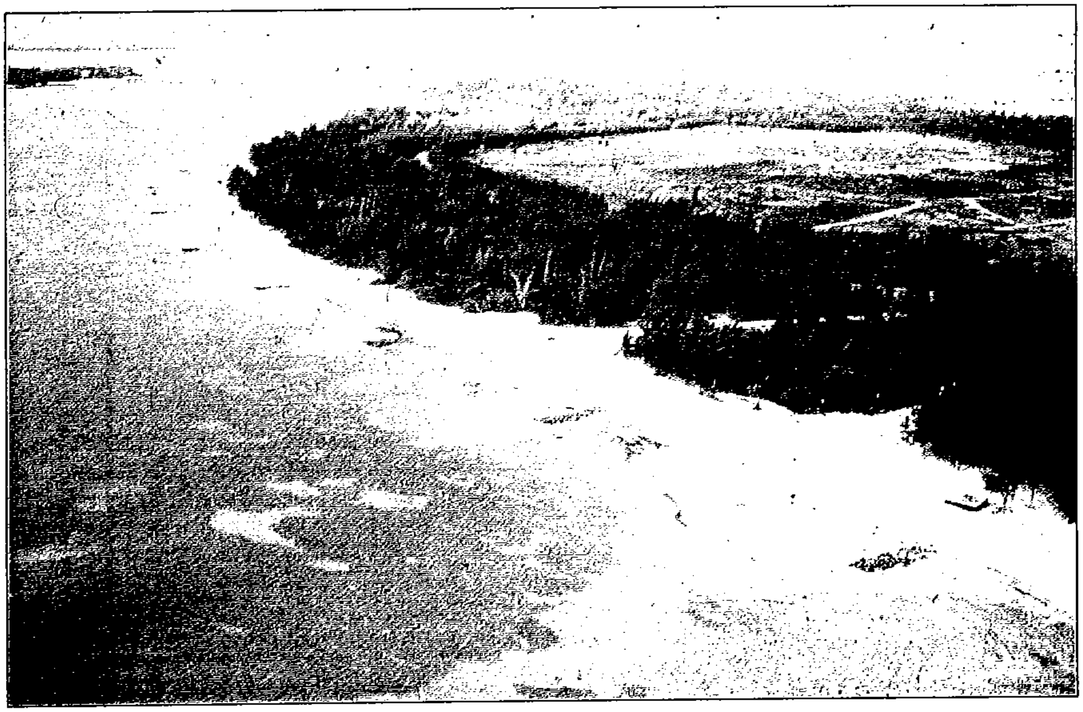


FIGURE 20: VIRGINIA KEY PHOTO - IMMEDIATELY AFTER CONSTRUCTION (1974)

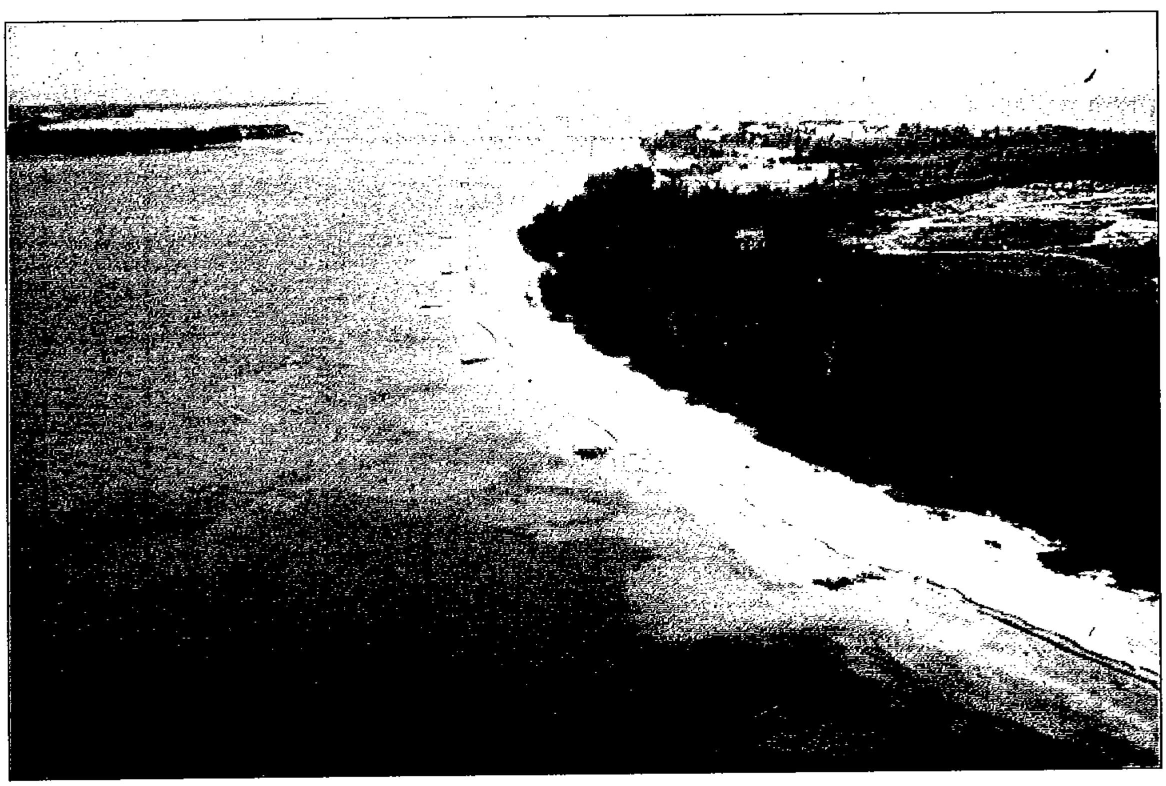


FIGURE 21: VIRGINIA KEY PHOTO - IMMEDIATELY AFTER CONSTRUCTION (1974)

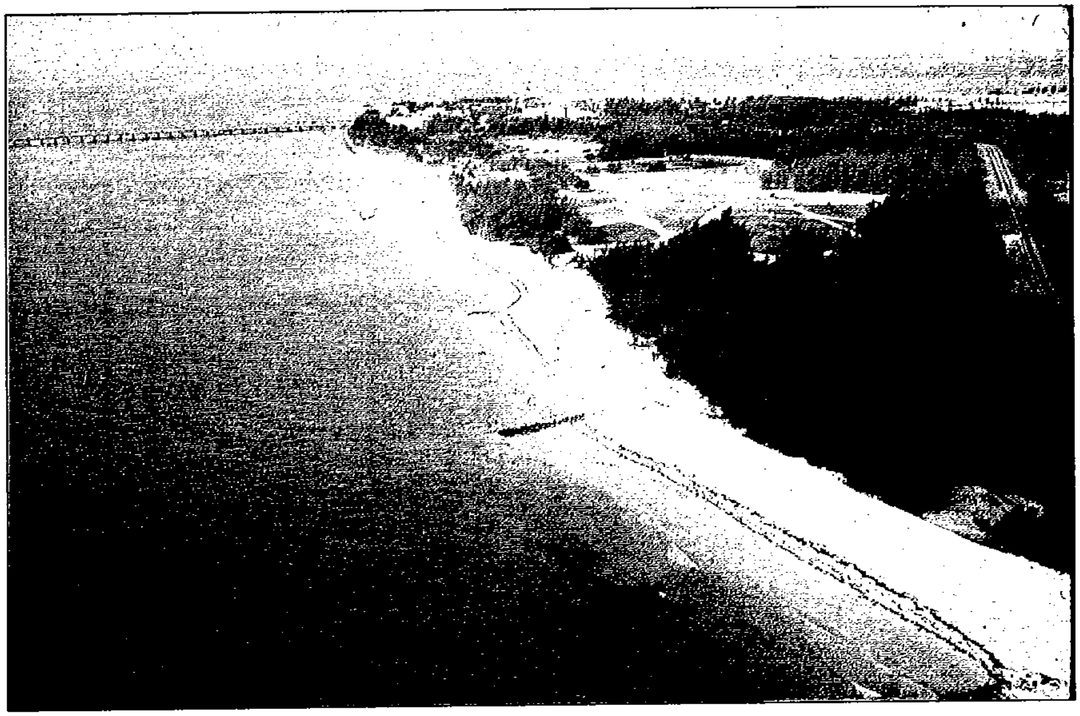


FIGURE 22: VIRGINIA KEY PHOTO - IMMEDIATELY AFTER CONSTRUCTION (1974)

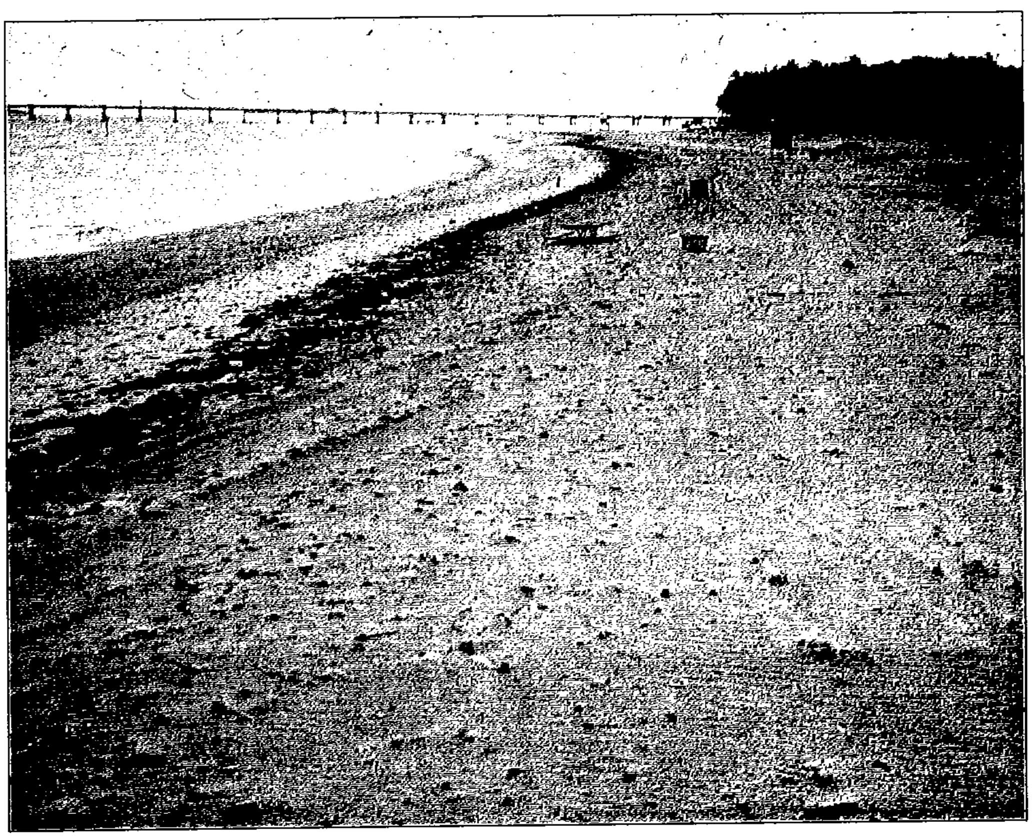


FIGURE 23: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (NOV 19, 1975)

FIGURE 24: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (NOV 19, 1975)

FIGURE 25: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (JAN 17, 1979)

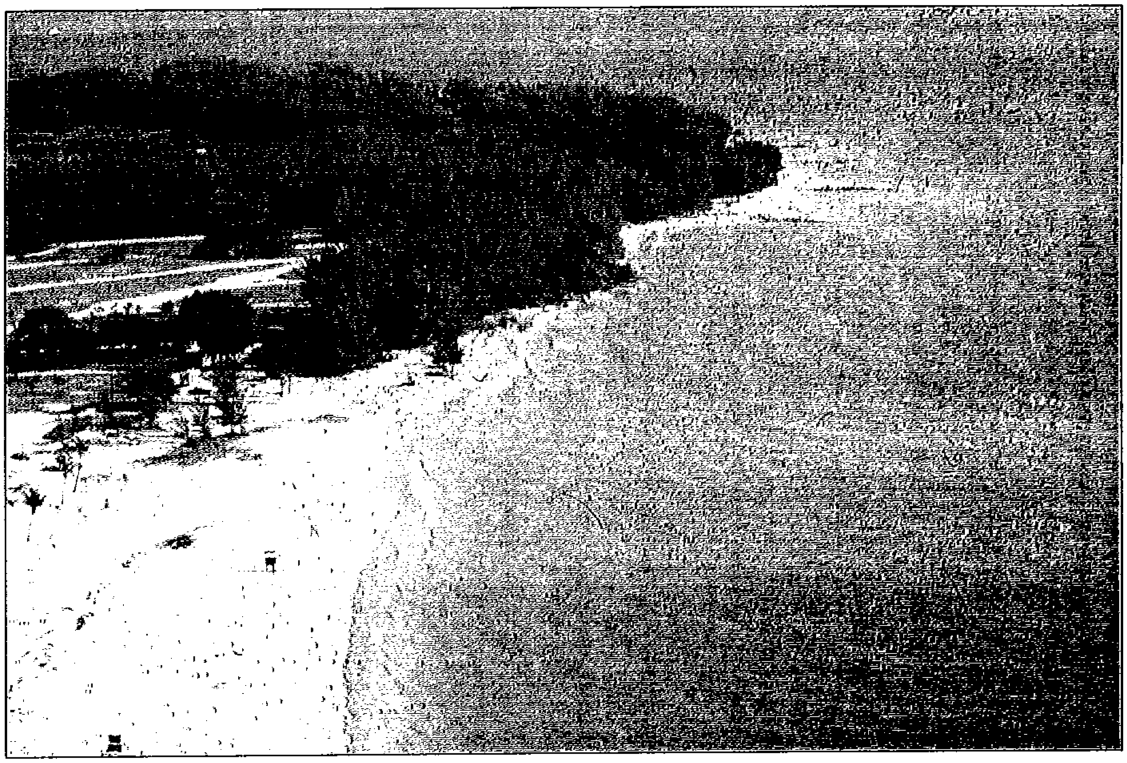


FIGURE 26: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (JAN 17, 1979)

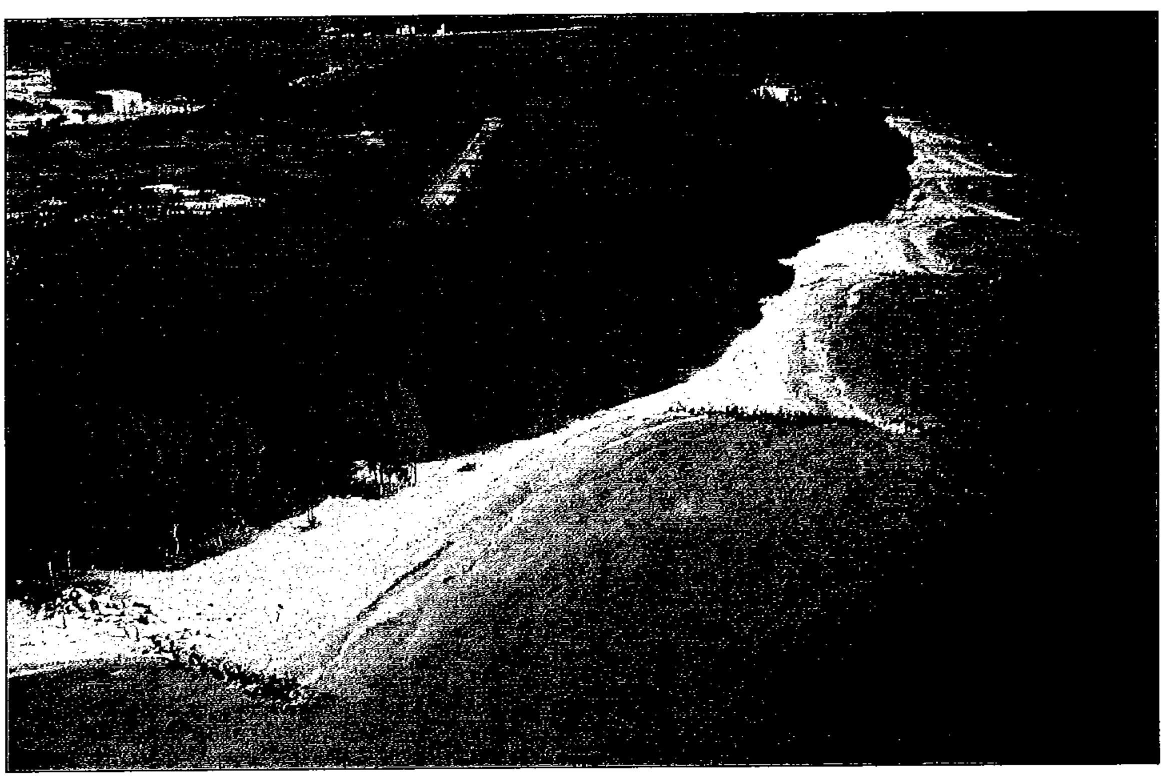


FIGURE 27: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (JAN 17, 1979)

FIGURE 28: AS-BUILT BEACH PROFILE (1992)

Storm Impacts

43. Several significant storm events have occurred since completion of the project construction on Virginia Key in 1974, Hurricane David in 1979, Hurricane Andrew in 1992, Hurricane Erin and tropical storm Jerry in 1995, the 1996 northeaster, and Hurricane Irene in 1999. These storms are discussed in more detail in the Engineering Appendix (Appendix A).

44. Hurricane Andrew, a Category 4 storm, was the third most intense storm to hit the United States in the twentieth century. The storm struck South Florida near Homestead at 4:00 am on Monday, August 24, 1992. Maximum sustained winds were measures at 145 mph. The storm surge along Key Biscayne's ocean shoreline was 10.1 ft at the northern end and 10.6 ft at the southern end. These surges were obtained by measurement of high water marks on structures on Key Biscayne. The natural elevation of Key Biscayne is 7 ft, and on Virginia Key 5 ft, relative to mean low water, indicating both islands were inundated during Hurricane Andrew. The pre-storm conditions of Virginia Key in January 1992 are shown in Figure 39. The conditions at the northern end of Virginia Key in June 1993 are shown in Figure 30. Site inspections of the rubble mound structures on September 2, 1992 indicated that the 13 rubble mound groins were intact and had retained fill in between the structures, even though the island was inundated.

FIGURE 29: VIRGINIA KEY PHOTO - ROCK GROIN FIELD (JUNE 1993)

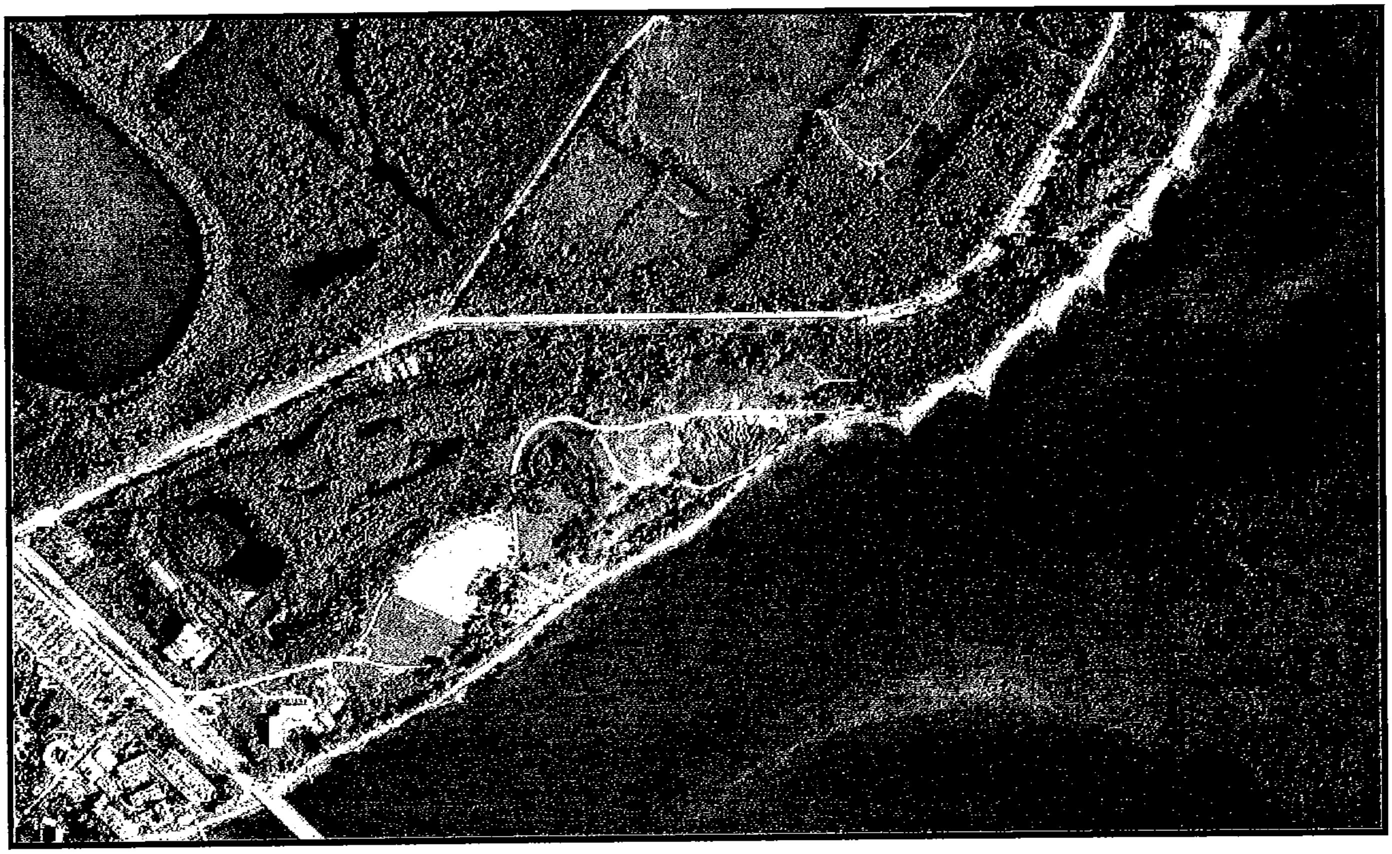


FIGURE 30: VIRGINIA KEY PHOTO, USACE, JACKSONVILLE (NOV 1999)

45. In order to quantify the storm-induced beach profile changes, an analysis of pre- and post-storm surveys was performed (USACE 84-99 Report, November 1992) (Appendix A). Beach profile lines (Figure 31) at approximately 1,000 ft intervals are located along the Virginia Key shoreline (monuments R79 through R86), and are maintained by the Florida Department of Environmental Protection (DEP). The Corps surveyed these beach profiles in September 1990. Following Hurricane Andrew, DEP surveyed all of the beach profile lines in Dade County to wading depth, including those for Virginia Key on August 26-29, 1992. Figure 32 shows the beach profile comparisons for R-83 and R-84. The comparative plots also include the as-built beach cross-section (shown in the figure as a 1 May 1977 survey), which was obtained from as-built drawings (D.O. File Nos. 24-31, 028 and 24-32, 479). Comparative analysis of profile lines R79-R82, R85 and R86 could not be made due to the relocation of the R monument between the two surveys. Given the presence of the various groins along Virginia Key's shoreline, comparison of surveys whose survey monuments had been relocated would result in grossly inaccurate estimates of beach profile changes.

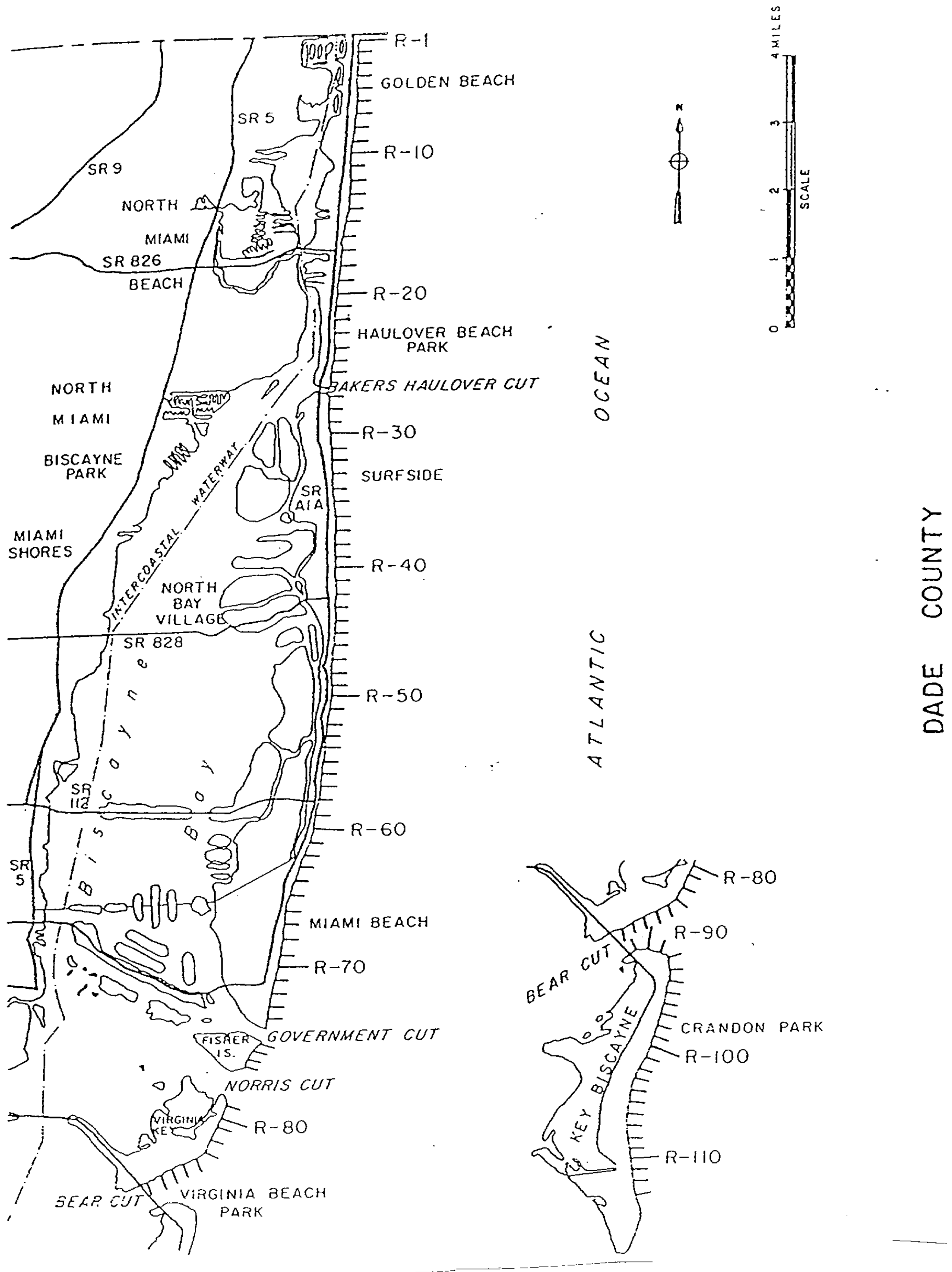
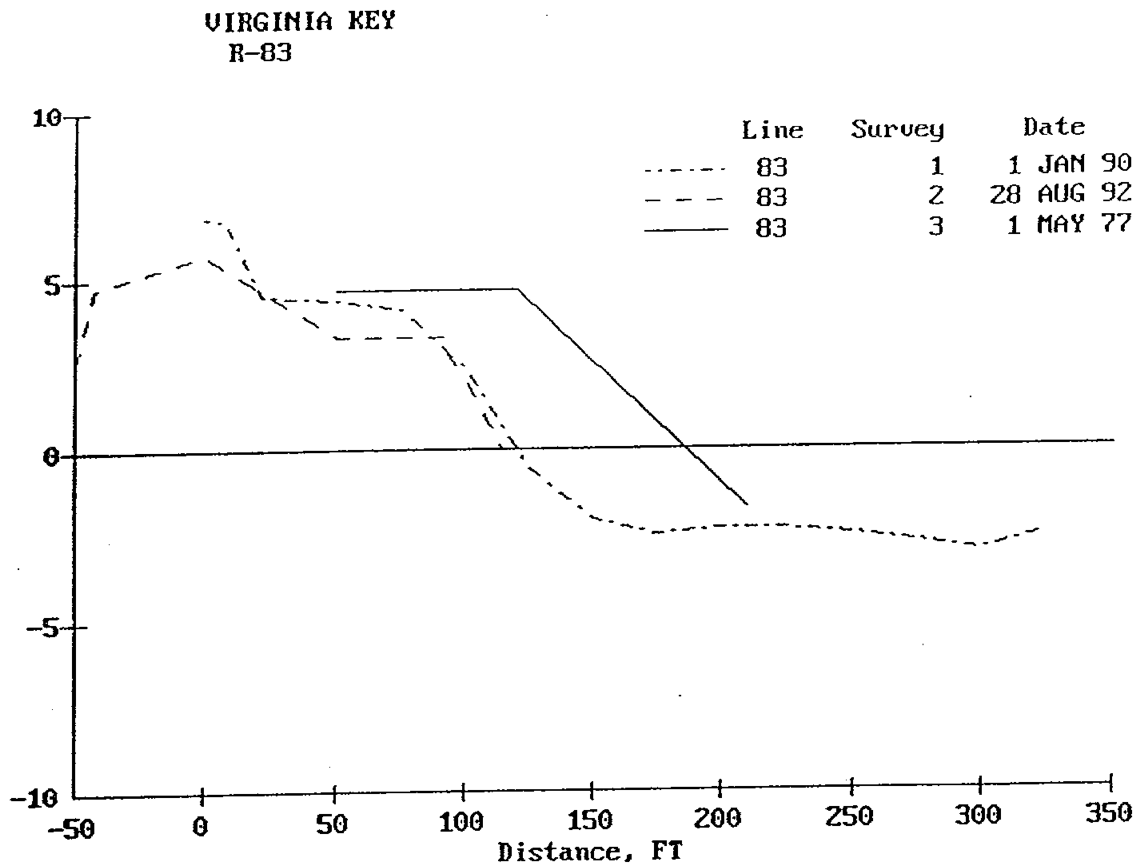


FIGURE 31: DADE COUNTY DNR MONUMENTS PROFILE LOCATION MAP



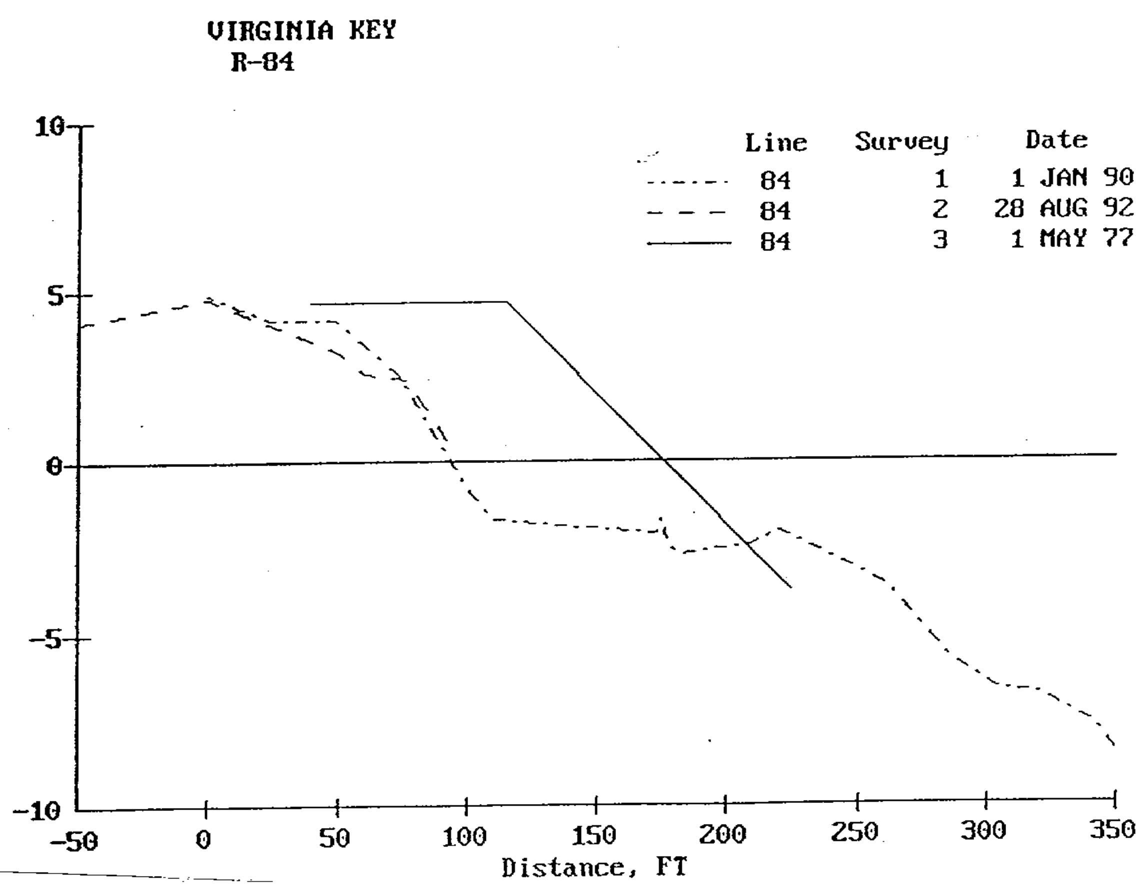


FIGURE 32: BEACH PROFILE COMPARISONS FOR DNR MONUMENTS R-83 AND R-84

46. The comparative beach profiles for R-83 and R-84 indicate that the beach fill placed in 1974 had largely eroded by 1990, prior to Hurricane Andrew. The storm had little impact on mean high water, with –1.0 ft of recession between the 1990 and 1992 surveys. Volume analysis indicates that the total net change in beach profiles for Virginia Key were a loss of 10,930 cubic yards. This is not a significant volume change, and only accounts for gains or losses of material from the dry beach area to NVGD. It was noted during the September 1992 site inspection that an offshore storm bar was observed. It is probable that the volume lost from the upper beach would be found if offshore surveys had been performed post-storm. This conclusion is supported by examining the aerial photographs in January 1992 (Figure 25) and June 1993 (Figure 27), which show little discernable difference in the condition of the beach.

Sediment Transport

47. Based on the available data, an average net volume of 24,000 cubic yards of material is transported southward along southern Dade County each year. This material is transported into the Miami Harbor entrance channel at Government Cut, where dredging records indicate that an average of 15,000 cubic yards per year shoals into the interior channels and 9,000 cubic yards per year shoals into the entrance channel. Another 25,000 cubic yards of material is likely lost to the offshore profile seaward of Government Cut. The Government Cut and jetties are a complete littoral barrier causing the loss of up to 49,000 cubic yards of material annually. No natural sand bypassing occurs at Government Cut.

Government Cut Impacts

48. The Virginia Key shoreline is influenced by three inlets: Government Cut, Norris Cut and Bear Cut. Government Cut is protected by jetties, which extend 2,000 to 2,500 ft seaward of the shoreline. The north jetty was essentially made sand tight in late 1959 and 1960. Prior to that time, littoral material was able to pass freely through the jetty. A general deficiency in supply of littoral material reaching Virginia Key has also been aggravated by the extensive groin systems on Miami Beach. As a result, severe erosion has been experienced in parts of the Virginia Key study area.

49. **Conclusions.** Based on prior reports and studies, it was determined that the shoreline at Virginia Key had basically stabilized. However, from subsequent research and data, it is apparent that the shoreline at Virginia Key has continued to erode. It is apparent that this erosion is directly related to construction activites at and around Miami Harbor. Though present year erosion rates were not obtained due to time constraints, it is anticipated that the shoreline would erode at a rate equal to or greater than the historical rates following construction of the initial beach fill of 1969. Therefore, the subsequent paragraphs will

discuss ways in which to address the erosion problems of the shoreline at Virginia Key.

ALTERNATIVE PLANS AND EVALUATIONS

50. **Initial Development of Alternatives.** Five possible solutions considered in the first step of plan formulation follows. Planning objectives, as previously discussed, were the basis for development of intermediate level detail and analysis. This section discusses the initial alternatives and selects those alternatives retained for furthur study.

a. Alternative 1: Without project or No-action.

b. Alternative 2: Beach fill only.

c. Alternative 3: Extend the Federal project by constructing rock groins the entire length of the shoreline with beach fill.

d. Alternative 4: Remove all timber groins and replace with similar structures and beach fill. Construct a single 440 ft long groin parallel to the shoreline.

e. Alternative 5: Remove all timber groins and replace with similar structures and beach fill. Construct 3 new timber groins.

51. **Screening of Initial Alternatives.** This section discusses the initial alternatives as previously listed. The no action alternative is carried throughout the plan formulation for the purpose of comparing the effects of other alternatives. The evaluation criteria for selecting the best alternative include, ability to stablize the shoreline, costs of construction, impacts to seagrasses, and effects on cross-shore and longshore velocities near the shoreline.

52. Based on the evaluation criteria, a number of the initial alternatives were eliminated from furthur evaluation. The eliminated alternatives were Alternative 2 and Alternative 4. Alternative 2, which consisted of beach fill only, was eliminated due to several factors. Firstly, beach fill without protective structures may contribute to a much more rapid rate of erosion of the unprotected shoreline. Secondly, beach fills generally tend to experience high initial losses following construction due to fill stabilization. Material is lost from the beach face as the front slope stabilizes, and large volumes of material can be lost from either end of the fill due to end (diffusion) losses, if not contained by some means. Thirdly, while beach fill serves to address the northern eroded area, the southern timber timber groin system will continue to deteriorate furthur, eventually leading to continued erosion of the shoreline. Therefore, this alternative was eliminated.

53. Alternative 4, which consisted of reconstructing the timber groins, beach fill and offshore breakwaters was eliminated due to environmental concerns as well as concerns over tidal currents. Offshore breakwaters would reduce shoreline erosion by reducing the amount of wave energy reaching the beach, thereby reducing littoral transport. However, several problems exist with construction of this alternative.

54. First, numerical modeling as well as field observations indicate that tidal currents through Bear Cut may be responsible for a portion of the sediment movement along this shoreline. The study area is well inside Bear Cut, and is protected from deepwater ocean waves by the 2-mile wide continental shelf, the extensive shallow sandbars of the Bear Cut ebb shoal, and by the protection provided by Virginia Key and Key Biscayne from northerly and southerly waves, respectively.

55. The construction of offshore breakwaters would have little effect on these tidal currents, and may even provide a minor degree of amplification of current velocities along the shoreline depending on breakwater location and orientation. A more serious problem is the presence of extensive seagrass beds along the Virginia Key shoreline. Seagrass beds exist throughout the nearshore zone along the entire length of the park, including the area considered for breakwater construction. Due to the presence of such extensive seagrass beds, breakwater construction may be difficult or impossible in this area due to the large area of seagrass which would be impacted. In addition, these offshore breakwaters would serve as a barrier in preventing sea turtles from accessing the beach to nest. Therefore, Alternative 4 was eliminated from furthur consideration. Alternatives 1, 3, and 5 will be carried forward to the detailed analysis phase.

56. **Intermediate Assessment of Alternative Plans.** A number of alternatives were examined as possible solutions for stabilizing the shoreline at Virginia Key. Various alternative plans were formulated during this study to ensure that all reasonable alternatives were evaluated. Three of the initial alternatives progressed to this stage. They will be discussed in greater detail in this section.

Hydrodynamic Modeling Analysis

57. Hydrodynamic modeling of Bear Cut was performed in order to simulate the effects of the proposed plans of improvement on current velocities throughout the project area. This modeling was performed using RMA-2 v4.3, which is a two-dimensional depth-averaged finite-element hydrodynamic numerical model. RMA-2 computes water surface elevations and horizontal velocity components for subcritical, free-surface flow in two dimensional flow fields. As part of the ongoing Biscayne Bay Feasibility Study, the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (CHL) was tasked with developing a two-dimensional finite element hydrodynamic and salinity transport model. A draft technical report titled "Development of a Two-Dimensional

Numerical Model of Hydrodynamics and Salinty for Biscayne Bay, FL" [Appendix A, References (m)] documents the development and verification of the model. The domain of the Biscayne Bay model includes the Virginia key study area. The portion of the Biscayne Bay model in the vicinity of Bear Cut was adopted and refined for use in the Virginia Key study. This resulted in considerable savings of time and cost associated with model development for the Virginia Key study.

58. Existing Condition Model Geometry. The existing condition shoreline was delineated from a high-resolution georeferenced color aerial photograph dated September 1999. The existing groin field was included in the model geometry based on interpretation of the photograph and GPS data points provided by Miami-Dade Department of Environmental Resource Management. The existing conditions for the model simulations are shown in Figures 17 and 18, Appendix A.

59. With-Project Model Geometry. The with-project model geometry includes the modified shoreline position based on the addition of beachfill along the eastern 1,300 feet of the park, addition of the three new groins along the same reach, and the removal of the seaward portions of several existing timber groins as described previously in this report, in order to remove these structures from the proximity of the seagrass beds. Since the proposed new groins and beachfill configuration are identical for all three proposed alternatives of improvement, and since the rehabilitated groins along the western portion of the park do not extend seaward of MLW in order to avoid seagrass impacts, this modified shoreline configuration corresponds to the groin field layout of all three alternatives, and is shown in Figure 19, Appendix A.

60. Model Output. Model output was post-processed to show changes in flow velocity between the two configurations. Velocity vectors at each node in the mesh from the with-project solution file were subtracted from the velocity vectors at each corresponding node in the existing condition solution file. This produced a scalar data set of the difference in velocity magnitude at each node in the mesh for all time-steps. The time-step that produced the largest differences was selected and a contour map of these differences is shown in Figure 19, Appendix A.

61. Model Results. Velocities within the model domain for both configurations range from 0.0 feet per second during slack tide to a maximum of 2.5 fps during the spring tide on the flood cycle. Maximum velocities are found in the deep part of Bear Cut channel approximately 750 feet offshore of the project area. In the shallow zone within 150 feet of the shoreline near the project features, velocities for the existing condition range from near zero to 0.8 fps. The changes in velocities predicted by the model as a result of the proposed shoreline modifications are shown in Figure 19, Appendix A. These velocity changes range from approximately –1.0 fps to +1.0 fps and are concentrated in limited areas adjacent to proposed project features. The velocities throughout the

remainder to the project area remain unchanged as a result of the proposed improvements.

62. Conclusions. The comparative numerical modeling shows that there will be virtually no changes in current velocities along the park's shoreline, except in the immediate vicinity of some of the proposed project features. These velocity changes are less than 1.0 fps in magnitude, even under the most severe tidal current conditions. Tidal current velocity changes throughout the majority of the lunar tidal cycle should be even lower than the values shown in, Figure 19, Appendix A.

Development of Detailed Alternative Plans

A. NO ACTION PLAN (Alternative 1)

Physical Description: This alternative involves allowing the shoreline at Virginia Key to furthur erode and allowing the timber groins to continue to deteriorate to the point of failing to stabilize the shoreline.

Cost and Benefits: No direct cost outputs or benefits.

Environmental Considerations: Detailed in Table 4.

Plan Optimization: This alternative does not resolve any of the shoreline erosion problems at Virginia Key.

Implementation Responsibility: None

Sponsor Views: This alternative is not acceptable to the sponsor.

B. STRUCTURAL PLAN 1 (Alternative 3)

Physical Description: This plan involves the removal of 25 existing timber groins and replacing them with eight rock groins the length of the shoreline. 2 rock groins will be constructed in the eroded area and the other 6 will constructed in the location of the existing timber groin system. The rock groins would be 175 ft in length and placed 425 ft apart. This plan also involves the placement of approximately 30,500 cubic yards of fill along the shoreline. Additionally, this plan involves construction of a 1,300 ft long, 2 ft high dune (approx. 710 cy) feature along the landward edge of the beach fill. See Appendix A for design.

Cost and Benefits: This plan has an estimated construction cost of $5,242,700. The beach at the Old County Park would be restored and stabilized. The Virginia Key Beach Park (Old County Park) would be preserved due to its historical nature and suitable for recreation.

Environmental Considerations: Detailed in Table 4.

Plan Optimization: Erosion rates along the entire shoreline would be reduced and the shoreline would be stabilized.

Implementation Responsibility: Federal Government.

Sponsor Views: This option is not acceptable to the sponsor.

C. STRUCTURAL PLAN 2 (Alternative 5)

Physical Description: This plan involves the removal of 25 existing timber groins and replacing them with 25 new timber groins. In addition, 3 new timber groins will be constructed in the severely eroded area. A total of 27 groins will be constucted the entire length of the shoreline. This plan also involves the placement of approximately 8,000 cubic yards of fill in the eroded area. Additionally, this plan involves construction of a 1,300 ft long, 2 ft high dune (approx. 710 cy) feature along the landward edge of the beach fill. See Appendix A for design details.

Cost and Benefits: This plan has an estimated construction cost of $1,462,900. The beach at the Old County Park would be restored and stabilized. The Virginia Key Beach Park (Old County Park) would be preserved due to its historical nature and suitable for recreation.

Environmental Considerations: Detailed in Table 4.

Plan Optimization: Erosion rates along the entire shoreline would be reduced and the shoreline would be stabilized.

Implementation Responsibility: Federal Government.

Sponsor Views: This plan is acceptable to the sponsor.

RATIONALE FOR SELECTING A PLAN

47. Four accounts are established to facilitate evaluation and display of the effects of alternative plans. These accounts are national economic development (NED), environmental quality (EQ), regional economic development (RED), and other social effects (OSE). These four accounts encompass all significant effects of plan implementation, including economic, socioeconomic and environmental criteria that must be considered in water resources planning as prescribed in the Federal laws.

a. National Economic Development (NED). This account displays changes in the economic value of the national output of goods and services.

b. Environmental Quality (EQ). This account displays non-monetary effects on significant natural and cultural resources.

c. Regional Economic Development (RED). This account registers changes in the distribution of regional economic activity that result from project construction. Evaluations of regional effects are to be carried out using nationally consistent projections of income, employment, output, and population.

d. Other Social Effect (OSE). This account registers project effects from perspectives that are relevant to the planning process, but are not reflected in the other three accounts.

48. The 1969 National Environmental Policy Act (NEPA), Public Law 91-190 (42 USC 4321) requires assessment of alternative plan impacts on the human environment and on significant EQ resources (40 CFR 1508.14). NEPA also requires documentation of the planning process, alternative plan comparison and plan selection.

49. Section 122 of the 1970 Rivers and Harbors Act (Public Law 91-611, 84 STATE. 1823) requires that for any proposed project, full consideration be given to possible adverse economic, social and environmental effects. It also requires that final decisions on the project are made in the best overall public interest, taking into consideration the need for flood control, navigation and associated purposes, and that the associated costs of eliminating or minimizing the adverse effects on the following:

- Air, water and noise pollution;
- Destruction or disruption of man-made and natural resources; aesthetic values;
- community cohesion; and availability of public facilities and services;
- Adverse employment effects;
- Tax an property value losses;
- Injurious displacement of people, businesses and farms;
- Disruption of desirable community and regional growth.

50. Section 209 of the 1970 Rivers and Harbors Act (Public Law 91-611, 84 STAT. 1829, 42 U.S.C. 1962-2), as amended by Section 227(f) of the 1996 Water Resources Development Act (Public Law 104-303, 110 STAT. 3703) expressed the intent of Congress that the objectives of enhancing regional economic development, the quality of the total environment, including its protection and improvement, the well-being of the people, and the national economic development are the objectives to be included in Federally financed water resource projects. In the evaluation of benefits and costs attributable thereto, due consideration must be given to the most feasible alternative means of accomplishing these objectives.

51. Section 904 of the 1986 Water Resources Development Act, Public Law 99-662 (100 STAT. 4185, 33 U.S.C. 2281), as amended by Section 315 of the 1990 Water Resources Development Act (Public Law 101-640, 104 STAT. 4641) describes additional requirements that must be addressed in the formulation and evaluation process for Federal water resources projects. These requirements are listed below. The formulation and evaluation process must consider the associated benefits and costs of these items, both quantifiable and unquantifiable, and must be displayed in the benefits and costs of such projects.

- Enhancing national economic development;
- Quality of the total environment, including preservation and enhancement of the environment;
- The well-being of the people;
- Prevention of loss of life;
- Preservation of cultural and historical values.

52. Section 905 of the 1986 Water Resources Development Act, Public Law 99-662) (100 STAT. 4185, 33 USC 2282) describes the requirements for feasibility reports for any water resources project or related study authorized to undertaken by the Secretary (of the Army). The feasibility report will describe, with reasonable certainty, the economic, environmental and social benefits and detriments of the recommended plan and alternative plans considered by the Secretary. It shall also include a description of a non-structural alternative to the recommended plan, when such plan does not have significant nonstructural features, and a description of the Federal and non-Federal participation in such plan. The report shall also demonstrate that the states, other non-Federal interests, and Federal agencies have been consulted in the development of the recommended plan.

53. Section 306 of the 1990 Water Resources Development Act, Public Law 101-640, (104 STAT. 4635, 33 USC 2316) mandates that environmental protection is a primary mission of the Corps in the planning, design, construction, operation and maintenance of water resources projects.

54. Section 307 of the 1990 Water Resources Development Act, Public Law 101-640, (104 STAT. 4635, 33 USC 2317) establishes, as part of the water resources development program, an interim goal of no overall net loss of the Nation's wetlands, as defined by acreage and function. The Act also prescribes a long-term goal to increase the quality and quantity of the Nation's wetlands, as defined by acreage and function.

55. Section 1(e)(2)(B)(ii) of Public Law 79-727 (33 U.S.C. 426e), as amended by Section 227(b) of the 1996 Water Resources Development Act, Public Law 104-303 (110 STAT. 3698-3699) requires that the Secretary consider the economic

and ecological benefits when making recommendations for shore protection projects.

56. The economic evaluation procedures to be used in Corps planning studies are the Water Resource Council's "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Federal economic criteria require that the selected plan be justified with sufficient benefits to exceed the costs and that the selected plan be the most economical means of meeting the planning objectives. Principles and Guidelines requires that the selected plan be determined using NED criteria, except as modified by non-Federal financial resource limitations or other explicitly stated criteria in accordance with the Principles and Guidelines, consistent with protecting the Nation's environment. Identification of the NED plan is to be based on consideration of the most cost-effective plans for providing different levels of water resources project outputs or level of service.

57. Planning criteria also require that the selected plan be technically and institutionally implementable. The institutional authority, financial capability, and overall support for the project by the non-Federal sponsor must be sufficiently established to allow recommendation of the selected plan as a Federal project, with the knowledge that it can be implemented. The plan must be acceptable to and indorsed by state, county and/or municipal authorities as a comprehensive solution to the water resources problems being addressed by this study.

58. In order to facilitate the evaluation and comparison of alternative plans, a table has been prepared (Table 4) which highlights the similarities and differences of the detailed alternative plans in solving the water resources problems identified in this study and report. This table also provides information to comply with NEPA documentation requirements.

Table 4: Summary of Effects			
Item	**No Action**	**Structural Plan 1**	**Structural Plan 2**
A. PLAN DESCRIPTION	Do nothing/Without Project Condition	Initial construction of rock groins and beach fill.	Initial construction of timber groins and beach fill.
B. IMPACT ASSESSMENT			
1. National Economic Development			
a. Beneficial Impacts (1,000s)			
(1) Damages Prevented	None, damages increase in time as erosion continues.	Future damages reduced as shoreline is stabilized.	Future damages reduced as shoreline is stabilized.
(a) Structures	None	Provide shoreline stabilization.	Provide shoreline stabilization.
(b) Coastal Armor	None	None	None
(c) Back Fill	None	Some required after groin construction.	Some required after groin construction.
(d) Land Loss	None	None	None
(2) Emergency Costs Avoided	N/A	N/A	N/A
(3) Land Enhancement	No impacts to land value.	Provides wider beach profile.	Provides wider beach profile.
(4) Recreation	No beneficial effects.	Allows park and beach to re-opened for public use.	Allows park and beach to re-opened for public use.
Total Beneficial Impacts	None		$915,540
b. Adverse Impacts			
(1) Project First Cost	None		$1,491,030
(2) Interest During Construction	None	None determined	$62,480
(3) Annual Charges	None	None determined	$100,280
Total Annual Costs	None	None determined	$114,920
c. Net NED Benefits	None	None determined	$800,620
d. Benefit-to-Cost Ratio	None	None determined	8.0 to 1
e. Enhance National Econonmic Development (NED)**	Tax and business revenues decline	Some increase in future revenues as revelopment brings visitors	NED is enhanced by the $800 thousand dollars in net benefits.
2. Environmental Quality (EQ)			
a. Beneficial Impacts			
(1) Water Circulation	No beneficial effect.	With rock groin lengths, circulation patterns are affected.	No beneficial effect.
(2) Manmade Resources *	No beneficial effect.	Park would be re-opened for public use due to the stabilization of the beach.	Park would be re-opened for public use due to the stabilization of the beach.
(3) Noise Level Changes *	No beneficial effect.	No beneficial effect.	No beneficial effect.
(4) Public Facilities *	No beneficial effect as park and beach are not currently open to public use.	Increased need as beach and park are re-opened for public use.	Increased need as beach and park are re-opened for public use.

Table 4: Summary of Effects			
Item	**No Action**	**Structural Plan 1**	**Structural Plan 2**
(5) Security of Life, Health, and Safety *	No beneficial effect.	N/A	N/A
(6) Tax Changes *	No beneficial effect.	Increase tax base as area develops.	Increase tax base as area develops.
(7) Aesthetic Values *	No beneficial effect.	The beach and Old County Park would be stabilized and suitable for recreation.	The beach and Old County Park would be stabilized and suitable for recreation.
(8) Natural Resources *	No beneficial effect.	Place 31,000 cubic yards of sand on beach as initial fill.	Place 8,000 cubic yards of sand on beach as initial fill.
(9) Biological Resources *	No beneficial effect.	No impact on manatees, whales or the American crocodile.	No impact on manatees, whales or the American crocodile.
(10) Air Quality *	N/A	N/A	N/A
(11) Water Quality *	No beneficial effect.	No beneficial effect.	No beneficial effect.
(12) Public Services *	N/A	N/A	N/A
(13) Cultural and Historical Preservation	No beneficial effect.	N/A	Constructing timber groins would maintain the historical character of the beach.
(14) Total Quality of the Environment **			
b. Adverse Impacts			
(1) Water Circulation	No increase.	No increase.	No increase.
(2) Manmade Resources *	No adverse effects.	Increases possibility of further development in beach areas.	Increases possibility of further development in beach areas.
(3) Noise Level Changes *	No adverse effects.	Temporary increase during construction. Increase due to larger beach crowds and more traffic to and from the beaches.	Temporary increase during construction. Increase due to larger beach crowds and more traffic to and from the beaches.
(4) Public Facilities *	No adverse effect	Increased need for water supply, sewer service, and other utilities as area develops.	Increased need for water supply, sewer service, and other utilities as area develops.
(5) Security of Life, Health, and Safety *	No adverse effect	No adverse effect	No adverse effect
(6) Tax Changes *	No adverse effect	Expenditures for project construction and maintenance.	Expenditures for project construction and maintenance.
(7) Aesthetic Values *	Continued accretion; relocation and modification may affect views in the area.	Temporary unsightliness during construction and nourishment.	Temporary unsightliness during construction and nourishment.
(8) Natural Resources *	No impact to nearshore seagrasses. Continued erosion of beach could impact upland and dune vegetation.	Beach fill would bury approximately 122,140 ft^2 of nearshore seagrass. Construction of rubble mound groins would cover approximately 37,050 ft^2 of seagrass. A benthic survey will need to be conducted to determine the presence of hard bottom communities	Beach fill would bury approximately 7,440 ft^2 of nearshore seagrass. Removal of the old timber groins would disturb approximately 500 ft^2 of seagrass. A benthic survey will need to be conducted to determine the presence of hard bottom communities and/or isolated corals in order

Item	No Action	Structural Plan 1	Structural Plan 2
		and/or isolated corals in order to determine effects.	to determine effects.
(9) Biological Resources *	Continued erosion could affect sea turtle nesting habitat and protected dune plant species.	Construction activities could impact sea turtle nesting or hatching if performed during the nesting season. Constructed rock groins could interfere with emerging nesting females or hatchings heading for the ocean. Temporary effect on benthic organisms at construction site.	Construction activities could impact sea turtle nesting or hatching if performed during the nesting season. Constructed groins could interfere with emerging nesting females or hatchings heading for the ocean. Temporary effect on benthic organisms at construction site.
(10) Air Quality *	No adverse effect	No adverse effect	Some decrease as number of visitors increase.
(11) Water Quality *	No adverse effect	Temporary increase in turbidity and suspended sediments during groin removal and construction and placement of beach fill.	Temporary increase in turbidity and suspended sediments during groin removal and construction and placement of beach fill.
(12) Public Services *	No adverse effect	No adverse effect	Increased need for water supply, sever service, and other utilities as recreational beach use increases.
(13) Cultural and Historical Preservation **	Continued erosion could potentially affect eligible historic properties within the Old County Park.	Not completely known at this time. To be determined after cultural resources surveys are completed. Replacing timber groins with rock groins would diminish the historical character of the beach.	Not completely known at this time. To be determined after cultural resources surveys are completed.
(14) Total Quality of the Environment **			
3. Regional Economic Development	Effects included in other 3 categories	"	"
4. Other Social Effects (OSE)			
a. Beneficial Impacts			
(1) Community Cohesion *	None	Increased leisure opportunity	Increased leisure opportunity
(2) Employment *	Continued erosion causes employment availability in beach areas to diminish.	Some local jobs during construction. Job availability in the future increases as beach is maintained.	Some local jobs during construction. Job availability in the future increases as beach is maintained.
(3) Tax Values *	Possible decline in project area.	Stabilized beach should enhance property values.	Stabilized beach should enhance property values.
(4) Community Growth *	Continued erosion would interfere with present growth trend.	Present growth trends would continue.	Present growth trends would continue.
(5) Property Values *	Decrease as erosion continues	Property values would be enhanced with construction of groins with periodic nourishment.	Property values would be enhanced with construction of groins with periodic nourishment.
(6) Displacement of Businesses *	None	Provides protection to future development.	Provides protection to future development.

Table 4: Summary of Effects

Item	No Action	Structural Plan 1	Structural Plan 2
(7) Public Facilities *	Continued erosion eventually affects availabe facilities.	Restoration of facilities may be required to realize the recreational beach use benefits.	Restoration of facilities may be required to realize the recreational beach use benefits.
(8) Injurious Displacement of Farms *	Not applicable.	Not applicable.	Not applicable.
b. Preservation of loss of life**	No effect.	No effect.	No effect.
C. PLAN EVALUATION			
1 . Contributions to Planning Objectives			
a. Protect from Storm-Induced Damages	Provides no protection.	Shoreline is better protected by construction of the structures and dune feature	Shoreline is better protected by construction of the structures and dune feature
b. Beach Erosion Control	Shoreline will continue to erode.	Erosion is reduced with structures	Erosion is reduced with structures
c. Protect Tourist Based Economy	Not applicable.	Not applicable.	Not applicable.
d. Provide Recreation Beach	No effect.	Not intended to create recreation beach.	Not intended to create recreation beach.
2. Response to Planning Constraints			
a. Financial capability of non-Federal partners cost share project construction.	No effect.	Project is 100% Federal cost.	Project is 100% Federal cost.
b. Institutional Acceptability	Not applicable	Acceptable	Acceptable
c. Public Acceptability	Not acceptable	Acceptable	Acceptable
3. Response to Evaluation Criteria			
a. Acceptability	Unacceptable to non-Federal Sponsor	Possibility of acceptance by non-Federal sponsor	Acceptable to non-Federal sponsor
b. Completeness	Does not address problems and needs of the project area	Partially addresses the problems and needs of the project area	Partially addresses the problems and needs of the project area
c. Effectiveness	Does not address problems and needs of the project area	Meets planning objectives	Meets planning objectives
d. Efficiency	Inefficient	Efficient in providing some degree of stability to the shoreline	Efficient in providing some degree of stablity to the shoreline and restores the groins
e. Certainty	Will not achieve any of the planning objectives	Will achieve the planning objectives	Will achieve the planning objectives
f. Reversibility	Could be reversed by implementing shoreline stabilization measures	Possible by removing the structures and allow shoreline to erode	Possible by removing the structures and allow shoreline to erode
D. IMPLEMENTATION RESPONSIBILITY	Interested county and state govenments.	Federal Government, non-Federal sponsor in cooperation with other concerned agencies in the State of Florida.	Federal Government, non-Federal sponsor in cooperation with other concerned agencies in the State of Florida.
E. STATE AND OTHER NON-FEDERAL COORDINATION***	None	U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental	U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental

Table 4: Summary of Effects			
Item	**No Action**	**Structural Plan 1**	**Structural Plan 2**
		Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer (SHPO), Florida Fish and Wildlife Conservation Commission, and the Florida Department of Environmental Protection	Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer (SHPO), Florida Fish and Wildlife Conservation Commission, and the Florida Department of Environmental Protection

* Items specifically required by Section 122 of Public Law 91-611 (84 STAT. 1823).
** Items specifically required by Section 904 of the 1986 Water Resources Development Act.
*** Items specifically required by Section 905 of the 1986 Water Resources Development Act.
**** Items specifically required by Section 306 of the 1990 Water Resources Development Act.
**** Items specifically required by Section 307 of the 1990 Water Resources Development Act.

SUMMARY OF PLAN FORMULATION

48. The comparison of the plans focuses on the differences among the alternative plans as determined during the evaluation phase. The selection is based on a comparison of the effects of the alternative plans against the costs and benefits associated with the no action plan.

49. The alternative plan with the greatest net economic benefit consistent with protecting the nation's environment, the NED plan, will be selected. The NED plan must also meet the test of four additional criteria:

a. <u>Completeness.</u> The extent to which a given modification of the authorized project provides and accounts for all necessary investments of other actions to ensure the realization of a reduction in shoreline damage.

b. <u>Effectiveness.</u> The extent to which a given modification of the authorized project contributes to a solution to the shoreline erosion and shoreline damage problems and achieves protection from shoreline erosion.

c. <u>Efficiency.</u> The extent to which a given modification of the authorized project is the most cost effective means of providing shoreline erosion protection, consistent with protecting the Nation's environment.

d. <u>Acceptability.</u> The viability of a given modification to the authorized project and its acceptance by the non-Federal project sponsor, state entities and the public, and compatibility with existing laws, regulations, and public policies.

SUMMARY OF PLAN COMPARISON

50. **Environmental Effects.** Implementing the proposed action would restore some of the beach's ability to provide protection against storms and flooding. It would also enhance the appearance and suitability for recreation at the Old County Park and would provide additional nesting habitat for threatened and endangered species of sea turtles. Removal of the existing deteriorated timber groins would disturb some seagrass adjacent to the structures. Seagrass would also be impacted by placing beach fill along the eastern 1,300 feet of the project area and by construction of one of the timber groins. Any impacts to seagrasses will be appropriately mitigated.

51. **Economic Considerations.** The economic benefits are detailed in Appendix B. All plans, except the no action plan, mitigate for erosion of the shoreline on Virginia Key. The least cost method of protecting the shoreline is structural plan 2.

52. **Conclusions**. Based on the evaluation criteria and impact comparisons, Alternatives 1 and 3 were eliminated from furthur evaluation. Alternative 1, the no-action plan, was eliminated due to several factors. Without protective structures in the severely eroded area, a more rapid rate of erosion of the unprotected shoreline may occur. The existing timber groin system would continue to deteriorate, increasing the likelihood of erosion of the shoreline near the Old County Park, potentially affecting eligible historic properties within this area. Continued erosion could also affect sea turtle nesting habitat and protected dune plant species. This alternative serves as the basis for comparison against the other alternatives.

53. Alternative 3, which consisted of removing the 25 timber groins and extending the Federal project with rock structures and beach fill, was eliminated due to environmental concerns and implementation costs. Firstly, this alternative involves the construction of 8 rock structures, each being 175 ft in length and spaced approximately 425 ft apart. The structures needed to be designed in this manner in order to maintain an acceptable beach area in much the same way as the 25 timber groins that currently exist.

54. Secondly, seagrass beds exist throughout the nearshore zone along the entire length of the park, including the area considered for groin construction. Due to the presence of such extensive seagrass beds, groin construction would impact these seagrasses. Construction of the rubble-mound groins would cover approximately 37,050 ft^2 of seagrass, while the beach fill would bury approximately 122,140 ft^2 of nearshore seagrass. In addition, these longer structures may also adversely affect sea turtle nesting.

55. Thirdly, the cost of this alternative rendered it impractical for selection as the alternative plan. This alternative, Alternative 3, incurred an estimated cost of

$5,242,770 as compared to the estimated cost of $1,462,900 for the timber groin design of Alternative 5. The timber groin design stabilizes the beach using a greater number of structures spaced more closely than the comparable rock structures and the timber groins are much shorter in length (1160 lf vs 1400 lf). The timber groins also blend well with the existing historical groins in the park. Therefore, Alternative 3 was eliminated from future consideration.

56. **Plan Selection**. The plan that satisfies the criteria necessary to stabilize the shoreline at Virginia Key, while minimizing environmental impacts, will be the selected plan. Due to uncertainties as to the condition of the buried upland portions of the existing timber groins, two methods of rehabilitation were examined: complete removal and replacement of the the total length of all 24 structures "Alternative 5a", and the repair of the damaged groin sections only "Alternative 5b". Cost estimates and details for both alternatives can be found in Appendix A. Because of the groin uncertainty condition, the worst case scenerio was chosen. Therefore, Alternative 5a was chosen as the selected plan (Figure 33).

THE RECOMMENDED PLAN

57. **Plan Components.** The components for the selected plan involve:

(1) Remove timber groins and concrete pilings. Involves the removal of 25 timber groins and the removal of 26 concrete king piles.

(2) Construct timber groins. Involves the construction of 28 timber groins along the 3,400-ft long shoreline. These groins will be placed approximately 150 ft apart and will vary in length based on seagrass proximity.

(3) Placement of fill material. The material used for beach fill will be excavated from an upland borrow area located near the project site on Virginia Key. This material will then be deposited into the severely eroded area located south of the Federal groin project. Approximately 5,000 cy of material will be deposited here.

(4) Construct dune feature. Involves the construction of a 1,300 ft long, 2 ft high dune along the landward edge of the beach fill. Approximately 710 cy of material will be deposited here.

(5) Disposal of timber groins and concrete piles. The timber groins and concrete piles are to be stockpiled within the park for future use by the local sponsor. See Figure 35.

FIGURE 33: SELECTED PLAN

ENGINEERING DESIGN AND CONSTRUCTION CONSIDERATIONS

DESIGN CONSIDERATIONS

Groin Materials

58. Several types of timber material were investigated for the construction of these three new groins. The design of these structures will be identical to the existing timber groins, except that the top elevations of these three groins will be raised from 4.0 feet to 5.0 feet mlw. Creosote-coated timber was used in the original construction of the timber groin field, but due to current environmental regulations this material cannot be used for the groin construction and repairs proposed in this study. The use of CCA (Copper, arsenic treated) timber has replaced creosote-coating, and will be investigated in this report. The use of "greenheart" wood from South America and the use of synthetic timber materials made primarily from recycled plastics were also considered in this report. In determining which material would be the most effective and cost-efficient, the advantages and disadvantages of each material were noted.

59. The wetted portions of the creosote-coated timber groins remained intact for at least 15-20 years, and the upland portions of the structures still appear to be in good shape today – over 50 years after the groins were constructed. Replacement of the creosote-coated timber with CCA-treated timber is recommended about every 15 years if the material is submerged (below mlw) or subjected to wetting and drying (intertidal zone). Greenheart wood requires less maintenance, but the initial cost is much higher. Periodic maintenance and replacement would still be required, although on a less-frequent basis than for CCA-treated timber. Problems with acquisition of this type of timber may be encountered from the provisions of the "Buy American Act" since this material is produced only in South America. Since no local supplier exists no cost data is available, and due to restrictions on imports created by the Buy American Act, the use of this material is not considered further.

60. The use of synthetic material also has a higher initial cost, but lower maintenance costs. The primary disadvantage of using synthetic material is that the material is generally much more flexible than wood and cannot be driven into the ground. Figure 3, Appendix A, shows that the main support piles and the vertical 3"x8" timber slats are each driven a minimum of several feet into the ground. Synthetic piles are not produced, and in any case neither the piles nor slats could be driven into place. Digging or jetting the materials into position would generate excessive turbidity near the seagrass beds, so the use of synthetic material was considered impractical and not considered further. Therefore, due to the disadvantages of using greenheart lumber and synthetic materials, and the proven performance of using treated timber, the use of CCA-

treated timber is recommended for construction of the three proposed new groins.

Groin Placement

a. New Groin Field

61. The new groin field in the eroded area was designed to provide maximum stability to this 1,300-ft reach of shoreline, while minimizing impacts to the seagrass areas. Three natural gaps in the seagrass beds occur at even intervals along this reach, roughly corresponding to the third-points along the length of this embayment. The spacing between these gaps is roughly 325 feet, which provides a transition between the 425-foot spacing of the rubble-mound groin field to the east, and the 100-foot spacing of the timber-pile groin field to the west. By placing groins within these areas impacts to seagrasses due to groin construction can be greatly reduced.

62. The lengths of the new groins were designed based primarily on sediment accumulation patterns along the adjacent groin fields. It was assumed that sediment would stabilize under the influences of waves and currents into the same general plan-view shapes observed in these adjacent groin fields. It was further assumed that sediment would bypass around the seaward edge of each of these impermeable structures in a 10-foot wide band, based on observations at the existing timber groins. In order to determine the design lengths of each groin, CADD software was used to overlay the DERM seagrass delineation onto a recent project aerial photograph. Groins of varying lengths were then overlaid onto this aerial photograph with corresponding stabilized beach fill configurations in order to determine the lengths of structures required to maintain a stable shoreline. Where possible, a minimum distance of 10 feet was maintained between the end of the groins and the landward edge of the seagrass bed, to reduce the environmental impacts due to sediment bypassing around the structures.

b. Existing Groin Field

63. The existing timber groin field has been in place since the 1940's and 1950's with very little shoreline erosion occurring along this area during that time. The will be based heavily on duplicating and restoring the successful design of the existing timber groin field along the entire length of the park.

64. The 25 existing timber groins vary in length from 30 to 80 feet, and most of these structures are spaced 100 feet apart. The restoration of the timber groin field will be based on rebuilding these structures to their original dimensions, using the same design for the original project construction. In order to minimize environmental impacts and maximize the effectiveness of the structures, three modifications to the groin field layout are recommended. First, the timber

portions of several groins extend into the seagrass beds, and it recommended that these portions of the groins be removed to minimize environmental impacts.

65. Secondly, removing the concrete king-pile sections of the timber groins will shorten some groins to the point where they are no longer effective, and it is recommended that these groins be extended seaward to replace some of the length of the king pile sections while remaining clear of the seagrass beds. Thirdly, the landward ends of several groins should be extended further upland to prevent flanking. The landward portion of several groins remain buried and it was not possible to determine the landward limit of these structures. In order to prevent flanking all groins should be extended landward to the vegetation or scarp line. More detailed information on specific modifications to each of the 25 timber groins is presented in Appendix A, Table 9 of this report.

66. Consideration was also given to reducing the number of timber groins to be re-constructed along the southeastern shoreline. This proved to be a condition that would cause more harm than good to the shoreline. The timber groins, in their current configuration, have stabilized the shoreline up to present date. If the number of groins is reduced, the new groins would need to be constructed in such a way as to retain material in much the same way as the current configuration. For this to occur, the new groins would have to be lengthened immensely and fill material would need to be placed, which would have a great impact on the seagrasses in the area. It was determined that the groins should remain in their current configuration as well as maintain the same number.

Concrete King Pile Removal

67. This will be the first item of work in the rehabilitation of the existing timber groin field. Ten groins near the center of the groin field were lengthened in 1965 by the addition of concrete king-piles. Each king pile is 2 feet x 2 feet in cross-section, and extends about 5 feet above mlw. Each pile contains vertical slots or grooves along the sides in which horizontal timbers can be placed to form a solid barrier. These piles were driven seaward of ten of the timber groins at 10-foot intervals, and horizontal 3"x8" timbers were placed in the slots to lengthen each of these groins by 10 or 20 feet. A photograph of a typical king-pile groin is shown in Figure 34. Most of the horizontal timbers have deteriorated, but each of the concrete king-piles remain. The existing groin field, although in a deteriorated condition, is holding the existing beach relatively stable. Therefore, lengthening the existing groins by replacing the wood panels between the king piles is not necessary. The king piles are a hazard and are to be removed as part of this project. A total of 26 piles are to be removed.

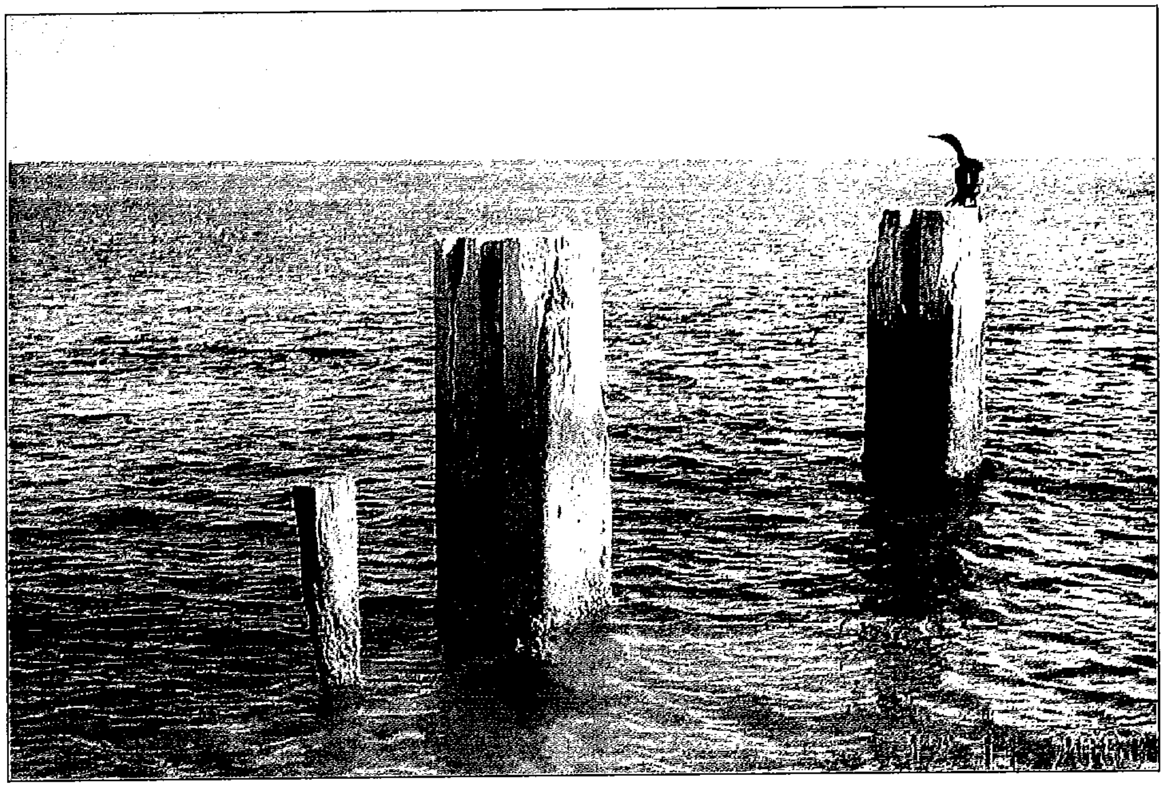


FIGURE 34: CONCRETE KING PILES (DEC 2000)

Beach Fill

68. For design of the beach fill, it was determined that some coverage of the nearshore seagrass beds would be unavoidable, due to the proximity of the landward edge of the seagrass to the existing shoreline. The beach fill configuration was designed to minimize impacts to these seagrass beds while still maintaining adequate beach widths for storm damage protection and recreation. The landward limits of seagrass along this 1,300-reach of eroded shoreline is shown in Figure 10, Appendix A.

69. Based on observations of the stabilized configurations of the shorelines between the existing rubble-mound and timber-pile groin fields, it was determined that the post-construction shoreline would stabilize with the new mlw line 10 feet landward of the seaward tip of the each new groin on the updrift (east) side of each groin. Some bypassing around the tip of each new groin would occur, so an effort was made to position the seaward tip of each groin at least 10 feet landward of the edge of seagrass where possible in order to minimize future impacts to the seagrass beds due to sediment movement around the structures.

70. Fill will be placed in a variable berm-width configuration to approximate the equilibrium shape of the beach, based on the shape of the existing pocket

beaches between the rubble-mound and timber-pile groins. By designing the beach fill to approximate the equilibrium shape of the beach, the volume of sediment transport following construction can be reduced greatly, minimizing erosional losses from the project and decreasing the risk of covering additional areas of the nearshore seagrass beds. The design berm elevation of +6.0 feet mlw corresponds to the authorized project berm elevation, and also corresponds to existing upland elevations along the fill area. Design data related to construction of the beach fill including volumes required, lengths of fills, and areas of seagrass impacts are shown in Table 7, Appendix A.

Source of Material

71. The primary borrow area for beach fill construction ("sand mound #2") is located adjacent to the shoreline at the east end of the park, and a smaller secondary borrow area ("sand mound #1") is located adjacent to the shoreline at the western edge of the park, as shown in Figure 34. Both borrow areas consist of large mounds of material dredged from near Key Biscayne which were stockpiled in these locations along the Virginia Key shoreline. The primary borrow area contains approximately 60,000 cubic yards of material, and the secondary borrow area contains approximately 12,000 cubic yards of material. The borrow material from each area is slightly finer than the existing beach material and contains about eight percent silt. Some rock and shell fragments are also observed in the two borrow sites, but the material has been determined to be compatible with the sediment on the existing beach along Old County Park.

72. Due to the proximity of the primary borrow area to the fill area (several hundred feet or less) and due to the adjacent environmentally sensitive seagrass areas, fill will be transported and placed using mechanical means such as front-end loaders, dumptrucks, and/or bulldozers. Hydraulic placement of fill is not allowable due to the adverse impacts on seagrass beds from the high turbidity levels which would be created by the outflow of the dredge slurry. Because of the similar characteristics between the borrow material and the native beach sediment, it was assumed that the beach fill would stabilize at a 1v:10h front slope, based on an analysis of existing front slopes along Virginia Key. Since beach fill will be placed mechanically, the front slope can be constructed at this equilibrium slope of 1v:10h, and minimal slope adjustment should occur.

73. Due to the configuration of the beach fill in the cells between the new groins, the order of work will specify that groin construction must be completed before beach placement begins. The only exception is that the contractor may opt for partial placement of the beach fill as a means of accessing the seaward portions of each groin during construction of these structures. In this case sand ramps would be constructed along each groin alignment to allow equipment access to the seaward portions of the groin construction sites. All fill placed in this manner would be required to remain within the limits of allowable beach fill placement shown in Figures 13 and 15, Appendix A.


Stockpile Areas
Barrow Mound #2
Stockpile Areas
Barrow Mound
Existing Timber Groins
Stockpile and Barrow Areas
FIGURE 35:

CONSTRUCTION CONSIDERATIONS

Method of Construction

74. Site Preparation. Prior to construction of the beach fill, various debris will be removed from the fill area, primarily along the eastern 1,300 feet of the park's shoreline. Erosion of that shoreline has resulted in the accumulation of numerous downed trees, exposed stumps, and large rocks which must be removed prior to construction of the beach fill. This debris will be hauled to an upland area of the park and sorted for disposal. All wood, plastic, and metal debris will be disposed of in a county landfill; all rock debris will be set aside for use in the county's artificial reef program.

75. Large areas of stiff clay and peat lie exposed along the eastern 1,300 feet of the park, and beach fill will be placed directly over these outcroppings. Several areas of loose rock also lie exposed along this reach of the park's shoreline, including the scattered remains of two relic rubble-mound groins. The stones from these two structures are approximately 1 – 2 feet in diameter and will be removed prior to fill placement and stockpiled for possible reuse as artificial reef material as described above. Any other stones greater than 1 foot in diameter lying within the footprint of the beach fill or in the nearshore region will also be removed and stockpiled. The majority of the stones which lie scattered along the beach are less than 6 inches in diameter, and will not be removed prior to fill placement.

76. Beach Fill. Due to the proximity of the borrow area to the fill area and due to the adjacent environmentally sensitive seagrass areas, fill will be placed using mechanical means such as front-end loaders, dumptrucks, and/or bulldozers. Hydraulic placement of fill is not allowable due to the adverse impacts on seagrass beds from the high turbidity levels which would be created by the outflow of the dredge slurry. The order of construction is to complete the three new timber groins first, then beach placement will begin. The contractor may opt for partial placement of the beach fill as a means to access the seaward portions of each groin during the initial phases of construction. In this case sand 'ramps' would be constructed along each groin alignment to allow construction equipment access to the groin construction sites. All fill placed in this manner would be required to remain within the allowable beach fill templates shown in Figure 11, Appendix A.

77. Dune Feature. Following completion of the beach fill, a small dune will be constructed along the landward edge of the berm along the eastern portion of the park. The dune will be 2 feet high with a 2-foot crest elevation and 1v:5h side slopes. The dune will be built in five 150-foot segments (930 feet overall), with 20-foot gaps between segments for beach access. A total volume of 710 cy of fill from either of the two borrow mounds will be used for dune construction. The

dune will be built using land-based earthmoving equipment in a manner similar to the construction of the beach fill.

78. Concrete King Piles. No subsurface geotechnical investigations have been performed in the project area, but based on a visual inspection of the surrounding area it is believed that the piles were driven primarily through sand, with some possible layers of stiff clay similar to the material exposed at the east end of the park. No detailed information is available to provide the depth to which these piles were driven, but it is believed that each pile extends no deeper than 15 feet into the ground, since this is the same penetration used for the piles which support the timber groins. Based on these types of sediment and the weight of the piles, a 50-ton crane should be more than adequate to remove the piles. The maximum distance offshore of the king piles is about 25 feet at low tide.

79. Most types of equipment that would be used for pile extraction can be positioned at or near the mlw line. The lifting capacity of any crane is dependent on the boom angle, so the closer the crane can be positioned to the pile, the more vertical the boom can be raised, and the greater the lifting capacity of the crane.

80. The seagrass beds extend landward to the mlw line along most of this length of shoreline, so no construction of sand ramps or any type of structure will be allowed in order to bring construction equipment closer to the piles. The construction of sand ramps to allow construction equipment over the landward portion of the groins is allowed, providing that the ramps are removed and pre-project grades are re-established along the beach following project completion.

81. The use of vibrating pile extractors will be allowed to facilitate the removal of these structures. In the event that some piles cannot be removed, upon the direction of the Corps representative the pile may be cut at a minimum of two feet below ground elevation. Turbidity curtains would be placed around the pile during excavation and cutting to minimize damages to the surrounding seagrass areas. Cutting of piles would be allowed only if all other reasonable methods of extraction fail. The piles are to be stockpiled within the park for future use by the local sponsor. The horizontal timbers between piles are to be disposed of off-site.

82. Restoration of Timber Groins. The existing timber groin field consists of 24 groins which were constructed along the western 2,100 feet of the Old County Park in 1948 and 1956, as described earlier in this report. In addition to investigating methods of stabilizing the eroded 1,300-foot portion of the Park's eastern shoreline, a secondary goal of this study is to determine methods of rehabilitating or reconstructing these historic timber groins. In order to accurately identify each of the existing timber groins, these structures are numbered consecutively from east to west, and do not include the three new structures which were described in the previous section of this report.

83. During a field inspection in December 2000 it was noted that each of the existing timber groins was almost totally deteriorated below the mlw line, and substantial deterioration had occurred in the intertidal zone, between mlw and mhw. The upland portions of each structure (above mhw) appeared to be in satisfactory condition, but most of the upland portion of each groin was buried, so an accurate appraisal of the condition of the entire structure was not possible. During this inspection, the lengths of the damaged portions of each groin were measured. Other measurements made during this inspection include the total length of each groin, the distance each groin extends into the seagrass bed, and the horizontal distance each structure extends seaward of mlw and mhw. All measurements include the lengths of the concrete king pile sections.

84. According to the original construction plans the vertical 3"x8" planks extend down to a depth of –4 feet mlw, and piles may extend downward to as much as –16 feet. Due to the deteriorated condition of these timbers, especially the piles, it may not be possible to extract all timbers completely. In order to avoid the complications of driving the new piles on top of the old piles, it is recommended that the fully reconstructed timber groins be offset about 5 feet on the downdrift (west) side of each existing structure.

85. By constructing on the downdrift side, the contractor would be able to place construction equipment further seaward (on the accreted material east of the original groins), and would generally have less pile-driving to perform since the beach profile is lower on the downdrift side of each of the existing groins. Using this methodology each new groin would be constructed prior to removing the corresponding old groin.

Operations and Maintenance (O&M)

86. Future operations and maintenance costs for the shoreline stabilization project consist of costs for inspection and anticipated repairs to the groins. Maintenance will occur at 20 year repair intervals since all materials will be new and in good condition upon completion of the initial construction. Following initial construction, replacement of the portions of each groin seaward of the mhw line will therefore be required at years 20 and 40. Maintenance costs will be $482,060 for each replacement of the timber groins in year 20 and 40. This equates to a present worth cost of $140,060 and $40,690 for repairs in years 20 and 40, respectively. Therefore, the total present worth value of all maintenance costs is $180,750.

Real Estate Requirements

87. All lands needed for project construction are located on property owned by the City of Miami and Dade County. A detailed description of the real estate requirements, real estate maps and cost estimates are provided in Appendix D of this report.

CONSTRUCTION COSTS

88. Construction costs include the engineering and design necessary for the project, preparation of contract plans and specifications, supervision and contract administration, construction monitoring, and costs for all temporary or permanent construction easements for land, easements, rights-of-way, relocations, borrow areas, and disposal areas. Costs for any environmental mitigation needed to replace environmental resources lost during construction, as well as costs for the identification and removal of any hazardous and toxic wastes are normally included. See Appendix A for details.

89. The estimated construction cost, including the first cost of the selected plan, is found in Table 5. All costs are based on February 2002 price levels. The cost estimates include 20 percent for project contingencies, $300,000 for planning, engineering design, and 10 percent for supervision and administration of project construction. The estimated length of construction is 12 months. Interest during construction is for an equal dispersion of payments over this 12-month period. There is also a 4-month preparation period for planning, engineering, and design (including plans and specifications).

Table 5: Construction Cost Estimate

Account Code	Item	Quantity	UOM	Contract	Contingency	Total Cost
A4	Mob/Demob					
1.0	Construction Features					
1.12.02.01.1	Mob/Demob & Prep Work	1.00	JOB	$29,100	$7,300	$36,400
	Subtotal: Construction Features				$7,300	$36,400
2.0	Non-Construction Features					
2.1	Engineering and Design	1.00	JOB		$10,600	$10,600
2.2	Construction Management	1.00	JOB		$4,700	$4,700
	Subtotal: Non-Const. Features					$15,300
	Total: Mob/Demob					**$51,700**
B4	Breakwaters and Seawalls					
1.0	Construction Features					
1.10.00.01. 1	Remove Existing Groin Field	10.30	CLF	$44,200	$11,000	$55,200
1.10.00.46.3	Concrete Pile Removal	26.00	EA	$39,400	$9,900	$49,300
	Construct New Timber Groins	15.40	CLF	$527,700	$131,900	$659,600
	Re-Plant Seagrass	850.00	SF	$14,400	$3,600	$18,000
	Subtotal: Construction Features					$782,100
2.0	Non-Construction Features					
2.1	Engineering and Design	1.00	JOB		$227,900	$227,900
2.2	Construction Management	1.00	JOB		$101,000	$101,000
	Subtotal: Non-Const. Features					$328,900
	Total: Breakwaters and Seawalls					**$1,111,000**
D2	Beach Fill					
1.0	Construction Features					
	Re-Plant Seagrass	7440	SF	$126,400	$31,600	$158,000
	Place Beach Fill	8050	CY	$30,600	$7,700	$38,300
	Construct 2' high berm	710	CY	$2,700	$700	$3,400
	Debris Clearing and Disposal	1	EA	$9,400	$2,300	$11,700
	Subtotal: Beach Fill					$211,400
2.0	Non-Construction Features					
2.1	Engineering and Design	1.00	JOB		$61,600	$61,600
2.2	Construction Management	1.00	JOB		$27,300	$27,300
	Subtotal: Non-Const. Features					$88,900
	Total: Beach Fill					**$300,300**
	Lands and Damages			22500	$5,625	$28,125
	Total: Additional Cost					$28,125
	Total: Construction Cost					$1,462,900
	Total: First Cost					**$1,491,030**
	Interest During Construction					$62,480
	Economic Investment					**$1,553,510**

ANNUAL PROJECT COSTS

90. The estimated first cost and annual cost for the selected plan are shown in Table 6. The first cost of $1,491,030 includes allowances for contingencies, engineering and design, and supervision and administration. The annual cost of $114,920 is based on an interest rate of 6 3/8 percent and a period of analysis of 50 years.

TABLE 6: TOTAL PROJECT COSTS	
ITEM	**COSTS**
FIRST COSTS	
Construction Costs	
Mob/Demob	$36,400
Breakwaters and Seawalls	$782,200
Beach Fill	$211,300
Total Construction Costs	$1,029,900
Non-Construction Costs	
Planning, Eng., and Design	$300,000
Construction Management	$133,000
Total Non-Construction Costs	$433,000
Real Estate Activities	
Lands and Damages	$0
Acquisition/Admin. Federal	$12,500
Acquisition/Admin. Non-Federal	$10,000
Contingency	$5,625
Total Real Estate	$28,125
	========
TOTAL FIRST COST	**$1,491,030**
ANNUAL PROJECT COSTS	
Interest and Amortization	$100,280
O&M	$14,640
	=======
TOTAL ANNUAL COST	**$114,920**

BENEFITS

91. Benefits that accrue to the proposed shoreline stabilization project are summarized in Table 7. Recreational benefits were computed using current data and procedures. Average annual benefits ($915,540) stemming from the selected plan compare with the annual cost ($114,920) of the selected plan to produce a ratio of 8.0:1. The derivation of recreational benefits is detailed in Appendix B.

TABLE 7: SUMMARY OF BENEFITS

TYPE OF BENEFITS	TOTAL
Recreation Benefits	$873,940
Loss of Land Benefits	$41,600
	=======
Total Benefits	$915,540
Benefit to Cost Ratio	8.0 to 1

92. In addition to recreational benefits, intangible benefits are also obtained from the re-opening of the Virginia Key Beach Park. The Virginia Key Beach Park is considered eligible for listing in the National Register of Historical Places. The Virginia Key Beach Park Trust has initiated a study to prepare National Register form to formally place the site on the register. An archival review and cultural resources survey will be conducted to locate and identify any significant prehistoric or historic properties within the area of potential effect for the proposed shoreline stabilization project.

PLAN IMPLEMENTATION

INSTITUTIONAL REQUIREMENTS

93. Section 101(e) of the Water Resources Development Act requires that before initiation of construction of a project, the Secretary of the Army and the non-Federal sponsor shall enter into a cooperative agreement according to the provisions of Section 221 of the 1970 Flood Control Act. The non-Federal interests must agree to:

1) Provide the Government all land easements, and rights-of-way, and to provide dredged material disposal areas, and perform the necessary relocations required for construction, operation, and maintenance of the project;

2) Hold and save the United States free from damages due to the construction or operation and maintenance of the project, except for damages due to the fault or negligence of the United States or its contractors; and

3) Provide to the Federal Government the non-Federal share of all other costs of construction of the project.

94. Section 912(b)(1) gives the Secretary the authority to required compliance with any requirements pertaining to cooperation by non-Federal sponsors in carrying out water resources project. These "items of cooperation" are listed in the Recommendations section of this report.

95. No Federal commitments relating to a construction schedule or specific provisions of the Project Cooperation Agreement (PCA) can be made to the non-Federal sponsor on any aspect of this project or separable element until:

1) The feasibility report has been approved by U.S. Army Corps of Engineers(USACE);

2) The project is authorized under the USACE discretionary authority; and

3) The project is budgeted as a new construction start, or construction funds are added by Congress; and

4) The draft PCA has been reviewed and approved by the Assistant Secretary of the Army for Civil Works.

96. **Project Cooperation Agreement (PCA).** The description of Federal and non-Federal responsibilities will be legally defined in the project cooperation agreement. A model PCA and possible deviations based on the recommended plan must be fully discussed with the non-Federal sponsor prior to the feasibility report review conference. This conference will include an agenda item to ensure that discussions with the non-Federal sponsor have taken place. The purpose is to ensure that the non-Federal sponsor will have a clear understanding of the type of agreement that they will be expected to sign prior to the start of construction. The Recommendations section of this report describes the items of local cooperation that the non-Federal sponsor will be required to furnish.

97. The PCA will not be executed nor will construction be initiated on this project until the National Environmental Policy Act, the Clean Water Act, the Coastal Zone Management Act, the Endangered Species Act, the Fish and Wildlife Coordination Act and the national Historic Preservation Act planning phase

requirements are met. These requirements are met for the Virginia Key Shoreline Stabilization Project once the draft Environmental Assessment has been coordinated, responses to comments prepared, and a Final Environmental Assessment and Finding of No Significant Impact signed.

98. PCA negotiations with the non-Federal project sponsor may be conducted, and the draft PCA package submitted to higher authority for review and approval once the feasibility report is approved and the project is budgeted for construction. The Chief of Engineers will not allocate Federal construction funds for the project until the non-Federal sponsor's financing plan is approved by the Government and the PCA is executed.

99. **Financial Analysis**. A financial analysis is required for any plan being considered by the Government for implementation that involves non-Federal cost sharing. The ultimate purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and have reasonable plans for meeting that commitment. The financial analysis shall include the non-Federal sponsor's statement of financial capability, the non-Federal sponsor's financing plan, and an assessment of the sponsor's financial capability. These plans and analysis are part of the draft PCA package submitted to higher authority for review and approval once the feasibility report is approved and the project is budgeted for construction.

DIVISION OF PLAN RESPONSIBILITIES

100. **Cost Allocation.** Section 111 of the 1962 River and Harbor Act, as amended specifies that the cost of water projects attributable to Federal navigation works for the purpose of mitigating for shoreline damage are in the same proportion as the costs for the project causing the damage. Additional guidance on Section 111 cost sharing is provided in Engineering Regulation 1105-2-100 dated 22 April 2000.

101. Costs of implementation and acquisition of lands, easement, rights-of-way, and suitable borrow and dredged or excavated material disposal areas (LERR&R) of project modifications undertaken pursuant to Section 111 are shared the same as the Federal navigation project causing the damage.

102. The feasibility phase studies and plans and specifications up to $100,000 will initially be fully funded by the Federal Government. Project modification proposals for implementation, which include study and plans and specification costs, greater than $100,000 shall be included as part of the total project modification costs to be shared 50 percent Federal and 50 percent non-Federal.

Cost Apportionment.

103. Federal Responsibilities. The U.S. Army Corps of Engineers is responsible for budgeting for the Federal share of construction costs for this project. The Federal share of construction costs is estimated at $1,393,540, or 100 percent of the total implementation costs. Federal funding is subject to budgetary constraints inherent in the formulation of a national Civil Works budget for a given Fiscal Year. The Corps would perform the necessary pre-construction, engineering and design needed prior to construction. The Corps would obtain all necessary permits, including water quality certification, and would construct the project.

104. **Non-Federal Responsibilities.** The non-Federal sponsor must assume other responsibilities before the project can be constructed. These "items of cooperation" are listed in the Recommendations section of this report. The delineation of Federal and non-Federal responsibilities are legally defined in the PCA.

105. The non-Federal sponsor shall also be responsible for 100 percent of the incremental operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs associated with the project modification. The non-Federal sponsor shall provide OMRR&R for the project modification in a manner so that reliability will not arise under the Comprehensive Environmental Response, Compensation and Liability Act.

106. In meeting its responsibilities, the non-Federal sponsor shall provide all LERRD required for project modifications which are not otherwise available due to the construction of the existing project. As a general rule, fee title will be required for all lands needed to support implementation, operation, maintenance, repair, replacement or rehabilitation of the project modification.

107. Further, the non-Federal sponsor shall accomplish, or arrange for accomplishment, at no cost to the Government, all relocations (excluding existing railroad bridges and approaches thereto) determined by the Government to be necessary for implementation of the project modification.

108. The non-Federal sponsor's responsibility for providing necessary interests in real estate required for the Section 111 project shall be the same as for the project causing the shore damage.

SUMMARY OF COORDINATION, PUBLIC VIEWS AND COMMENTS

109. Interagency collaboration throughout all stages of project development and implementation is paramount to the success of the Civil Works Program. Scoping for the proposed action was initiated during the reconnaissance phase by a letter dated July 24, 2000. A second scoping letter was issued on January

29, 2001 for the feasibility phase of the study. The scoping letters were distributed to the appropriate Federal, State and Local agencies, appropriate city and county officials, and other parties known to be interested in the project. Copies of the scoping letters, the list of addressees used to distribute the letters, and letters of response are included in Appendix C, Pertinent Correspondence. A Notice of Availability (NOA) of the draft EA will be prepared and sent to appropriate Federal, State and Local agencies, appropriate city and county officials and other interested parties.

110. The proposed project has been coordinated with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer (SHPO), Florida Fish and Wildlife Conservation Commission, and the Florida Department of Environmental Protection. Any agency coordination letters are in Appendix C.

111. The minimum 30-day NEPA document review by concerned agencies, organizations and the interested public will be initiated both after the FRC and approval of the draft report for release. The coordination will be completed prior to transmittal of the feasibility report to higher authority for final review and approval. This process in no way prohibits or restricts the involvement of other federal and State agencies during the development of the NEPA document.

COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

National Environmental Policy Act of 1969

112. Environmental information on the project has been compiled and this Environmental Assessment has been prepared for public review and comment. The project is in compliance with the National Environmental Policy Act.

Endangered Species Act of 1973

113. In a letter dated February 8, 2001 the Corps submitted project information to the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act. In the letter the Corps had determined that the proposed project activities were covered under the Regional Biological Opinion (RBO) concerning hopper dredging on the South Atlantic Coast as amended on September 25, 1997. The Corps also requested informal consultation for Johnson's seagrass until it can be to be present or not in the vicinity of the project area. This consultation is still ongoing. In a letter dated February 12, 2001 the Corps submitted a Biological Assessment to the U S Fish and Wildlife Service (USFWS) pursuant to Section 7 of the Endangered Species Act. This consultation is still ongoing. Refer to Appendix C for correspondence. Pending the conclusion of the Section 7 consultations with NMFS and USFWS this project will be in full compliance with the Act.

Fish and Wildlife Coordination Act of 1958

114. This project has been coordinated with the U.S. Fish and Wildlife Service (USFWS). A Draft Coordination Act Report (CAR) dated March 2001was submitted by the USFWS (refer to Appendix D). This project is in full compliance with the Act.

NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA)

115. (PL 89-665, the Archeology and Historic Preservation Act (PL 93-291), and executive order 11593) Archival research, field investigations and consultation with the Florida State Historic Preservation Officer (SHPO), has been conducted in accordance with the National Historic Preservation Act, as amended; the Archeological and Historic Preservation Act, as amended and Executive Order 11593. A determination of no adverse effect was sent to the SHPO on January 10, 2001. In a letter dated January 17, 2002, the SHPO concurred with the determination. At this stage, the project is in compliance with each of these Federal laws.

Clean Water Act of 1972

116. The project is in compliance with this Act. Application for a Section 401 water quality certification will be submitted to the Florida Department of Environmental Protection. All State water quality standards would be met. A Section 404(b) evaluation is included in this report as Appendix A.

Clean Air Act of 1972

117. Refer to Section 4.11 in this EA, which discusses compliance with the Clean Air Act General Conformity Rules. No air quality permits would be required for this project. This project has been coordinated with the U.S. Environmental Protection Agency (EPA) and is in compliance with Section 309 of the Act. The Draft EA will be submitted to EPA for their review.

Coastal Zone Management Act of 1972

118. A federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as Appendix B. State consistency review will be performed during the coordination of the draft EA. The State has determined that, at this stage, the project is consistent with the Florida Coastal Zone Management Program.

Farmland Protection Policy Act of 1981

119. No prime or unique farmland would be impacted by implementation of this project. This act is not applicable.

Wild and Scenic River Act of 1968

120. No designated Wild and Scenic river reaches would be affected by project related activities. This act is not applicable.

Marine Mammal Protection Act of 1972

121. Incorporation of the safe guards used to protect threatened or endangered species during construction operations would also protect any marine mammals in the area, therefore, this project is in compliance with the Act.

Estuary Protection Act of 1968

122. No designated estuary would be affected by project activities. This act is not applicable.

Federal Water Project Recreation Act

123. This Act does not apply.

Fishery Conservation and Management Act of 1976

124. The project has been coordinated with the National Marine Fisheries Service (NMFS) and is in compliance with the act (refer to correspondence in Appendix C from NMFS).

Submerged Lands Act of 1953

125. The project would occur on submerged lands of the State of Florida. The project has been coordinated with the State and is in compliance with the act.

Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990

126. There are no designated coastal barrier resources in the project area that would be affected by this project. These acts are not applicable.

Rivers and Harbors Act of 1899

127. The proposed work would not obstruct navigable waters of the United States. The project is in full compliance.

Anadromous Fish Conservation Act

128. Anadromous fish species would not be affected. The project has been coordinated with the National Marine Fisheries Service and is in compliance with the act.

Migratory Bird Treaty Act and Migratory Bird Conservation Act

129. No migratory birds would be affected by project activities. The project is in compliance with these acts.

Marine Protection, Research and Sanctuaries Act

130. The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal (i.e. groin construction). Therefore, the Marine Protection, Research and Sanctuaries Act does not apply to this project. The disposal activities addressed in this EA have been evaluated under Section 404 of the Clean Water Act.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

131. This act requires preparation of an Essential Fish Habitat (EFH) Assessment and coordination with the National Marine Fisheries Service (NMFS). The EFH Assessment has been integrated within the Draft EA and will be coordinated with NMFS during the normal NEPA coordination.

E.O. 11990, Protection of Wetlands

132. No wetlands, as define in the Executive Order, would be affected by project activities. This project is in compliance with the goals of this Executive Order.

E.O. 11988, Flood Plain Management

133. The proposed project is in the base flood plain (100-year flood) and has been evaluated in accordance with Executive Order 11988. Relocation of the project outside of the flood plain would not be responsive to the shoreline stabilization needs of the Virginia Key Shoreline Stabilization Project, and was not considered further. A non-flood plain alternative for the potential development that may be induced as a result of project implementation would be to restrict all future development to those areas outside of the flood plain or elevated above the flood plain. Potential flood plain development as a result of project implementation would not likely occur as Dade County has designated the property as a restoration site.

E.O. 12898, Environmental Justice

134. The proposed action would not result in adverse human health or environmental effects, nor would the activity impact subsistence consumption of fish and wildlife. The project is in compliance.

E.O. 13089, Coral Reef Protection

135. The proposed action would not affect U.S. coral reef ecosystems as define in the Executive Order. Project is in compliance.

E.O. 13112, Invasive Species

136. The proposed action will not affect the status of any invasive species. Project is in compliance.

CONCLUSIONS

137. This report summarizes planning, engineering and design studies of Virginia Key to determine whether the Federal navigation project at Miami Harbor, Florida has caused adverse impacts, and to determine appropriate mitigation measures and the level of Federal interest. A harbor mitigation project to prevent shoreline erosion on Virginia Key has been found to be economically justified and it the Federal interest. The recommended plan provides the most economical means of stabilizing the shoreline with the least amount of environmental impacts.

RECOMMENDATIONS

I have given consideration to all significant aspects for the proposed shoreline stabilization of Virginia Key in the overall public interest, including engineering and economic feasibility, environmental and social effects. The recommended plan described in this report provides the optimum solution for shoreline stabilization of the study area that can be developed within the framework of the formulation concepts.

I recommend that the Miami Harbor Federal navigation project be modified under the general authority of Section 111 of the River and Harbor Act of 1968, as amended, for the purpose of shoreline stabilization of Virginia Key at Virginia Key, Florida, as described herein, with such modifications as in the discretion of the Chief of Engineers may be advisable.

This recommendation is made with the provision that prior to project implementation, the non-Federal sponsor shall enter into a binding agreement with the Secretary of the Army or his designated representative to perform the following items of operation:

a. Pay 100 percent of any operation, maintenance, repair, replacement, and rehabilitation costs attributable to the Project.

b. Provide all land easements, and rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the implementation, operation, and maintenance of the Project;

c. Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the implementation, operation, and maintenance of the Project. Such improvements may include, but are not limited to, retaining dikes, water weirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps and pipes;

d. Provide during implementation, any additional amounts as are necessary to make its total contribution equal to 25 percent of the project costs;

e. For as long as the Project remains authorized, to operate, maintain, repair, replace, and rehabilitate the completed Project, or functional portion of the Project, at no cost to the Federal Government, in a manner compatible with the Project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific direction prescribed by the Federal Government;

f. Grant the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the Non-Federal sponsor owns or controls for access to the Project for the purpose of inspection, and, if necessary for the purpose of completing, operating, maintaining, replacement, or rehabilitating the project;

g. Hold and save the United States free from all damages arising from the implementation, operation, maintenance repair, replacement, and rehabilitation of the Project and any Project related betterment, except for damages due to the fault or negligence of the United States or its contractors;

h. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the Project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations(CFR) Section 33.20;

i. Perform, or cause to be performed, any investigations for hazardous substances as are deemed necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, rights-of-way, that the Federal Government determines to be required for the implementation, operation, and maintenance of the Project except for any such lands that the Federal Government determines to be subject to the navigation servitude. The Government shall perform, or cause to be performed, all investigations on lands, easements, or rights-of-way that are owned by the United States and administered by the Federal Government. For lands that the Federal Government determines to be subject to navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the Non-Federal sponsor with prior specific written direction, in which case the Non-Federal sponsor shall perform such investigations in accordance with such written direction;

j. Assume complete financial responsibility, as between the Federal Government and the Non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the implementation, operation, or maintenance of the Project Modification, except for any such lands, easements, or rights-of-way owned by the United States and administered by the Federal Government;

k. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the Project in a manner that will not cause liability to arise under CERCLA;

l. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the implementation, operation, and maintenance of the Project Modification, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

m. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army";

The recommendations contained herein reflect the information at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are authorized under the general provisions of Section 111 of the River and Harbor Act of 1968, as amended, and considered for implementation funding. However, prior to authorization, the sponsor, the City of Miami, interested State and Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

James G. May
Colonel, Corps of Engineers
District Engineer

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US Army Corps of Engineers, 84-99 Report, Virginia Key and Key Biscayne Beach Erosion Control Project, Dade County, Florida, November 1992.

FEBRUARY 2002

Draft Environmental Assessment

SECTION 111 SHORELINE STABLIZATION
Virginia Key, Dade County, Florida

U.S. Army Corps
of Engineers
Jacksonville District

PRELIMINARY
FINDING OF NO SIGNIFICANT IMPACT

SECTION 111 SHORELINE STABILIZATION
VIRGINIA KEY, DADE COUNTY, FLORIDA

I have reviewed the Environmental Assessment (EA) for the proposed action. This Finding incorporates by reference all discussions and conclusions contained in the Environmental Assessment enclosed hereto. Based on information analyzed in the EA, reflecting pertinent information obtained from agencies having jurisdiction by law and/or special expertise, I conclude that the proposed action will not significantly impact the quality of the human environment and does not require an Environmental Impact Statement. Reasons for this conclusion are in summary:

a. The proposed action would restore a section of severely eroded beach at Virginia Key, Florida thus preventing or reducing loss of public beachfront to continuing erosional forces and preventing or reducing periodic damages and potential risk to life, health and property in the developed lands adjacent to the beach.

b. Measures to prevent or minimize impacts to sea turtles in accordance with Biological Opinions from the U.S. Fish and Wildlife Service and the National Marine Fisheries Service will be implemented during and after project construction. To protect the manatee, any water-based activities would follow standard manatee protection measures. There would be no adverse impacts to other Federally listed endangered or threatened species.

c. Pending the State's concurrence with the Federal Coastal Zone Consistency Determination (Appendix B of the EA), the action is consistent with the State's Coastal Zone Management program.

d. Based on historic property field investigations, no potentially significant cultural resources are located in the areas proposed for construction. The Corps has determined that the proposed project will have no effect on historic property. The Florida State Historic Preservation Officer has concurred with this determination.

e. The State water quality standards will be met. Turbidity monitoring will be performed during construction to ensure turbidity levels do not exceed the State water quality standard.

f. Measures to eliminate, reduce, avoid and/or mitigate for potential impacts to fish and wildlife resources will be implemented during construction.

James G. May
Colonel, U.S. Army
District Engineer

Date

DRAFT ENVIRONMENTAL ASSESSMENT

SECTION 111 SHORELINE STABILIZATION
VIRGINIA KEY, DADE COUNTY, FLORIDA

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VIRGINIA KEY, DADE COUNTY, FLORIDA

1 PROJECT PURPOSE AND NEED

1.1 PROJECT AUTHORITY.

A Section 905(b) preliminary assessment was conducted in response to a letter dated July 25, 2000 from U.S. House of Representatives' Carrie P. Meek. The 905(b) assessment indicated that further detailed study was warranted to determine if mitigative measures were appropriate at Virginia Key due to negative impacts from previous improvements of the Federal navigation project at Miami Harbor.
The feasibility study is being conducted under the Corps' continuing authority provided by Section 111 of the River and Harbor Act of 1968, as amended. Section 111 reads as follows:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damage attributable to Federal navigation works. The cost of implementing measures under this authority would be shared by non-Federal interests in the same proportion as the costs for the project causing the damage. The cost of operating and maintaining such projects shall be borne entirely by the non-Federal interests. No such project shall be constructed without specific authorization by Congress if the estimated first cost exceeds $5,000,000."

1.2 PROJECT LOCATION.

Virginia Key is a barrier island located along Eastern Biscayne Bay on the Atlantic coast of Dade, County, Florida, south of Miami Beach and north of Key Biscayne. Virginia Key is located in close proximity just south of Miami Harbor. A location map and aerial photograph of the area is shown in figure 1. Rickenbacker Causeway provides access to the island from the mainland. The study area is located along a 3,400-foot length of the southeastern shoreline of Virginia Key (figure 2). The northern limit of the study area is located at the southern limit of the existing Federal groin construction project, which was completed in 1974. The Federal project consists of a series of rubble-mound groins along the northeast shoreline if the island. The study area extends south from the Federal project along an area known as the "Old County Park." This park is owned by the City of Miami and is currently closed to the public. The southern limit of the study area is located at the boundary between the park and the Southeast Fisheries Science Center, and is about 300 feet north of the Rickenbacker Causeway Bridge that crosses Bear Cut. The study area consists of two separate regions. A relic timber groin field exists along the southern 2,100 feet of the study area. The northern 1,300 feet of the study area consists of an unprotected length of shoreline between the relic groin field and the southernmost rubble-mound groin of the Federal project (figure 2).

1.3 PROJECT NEED OR OPPORTUNITY.

A number of problems are being experienced at Virginia Key, which are attributable to the Federal navigation project at Miami Harbor. Construction activities at Miami Harbor have caused a decrease in the amount of sediment transported to the beaches on the southern end of Virginia Key. In addition wind generated waves and swells, tides and currents, and hurricanes and storms also contribute to the deterioration of the shoreline at Virginia Key.

1.4 AGENCY GOAL OR OBJECTIVE.

The purpose of this study is to determine the feasibility and Federal interest in modifications to Virginia Key as a result of the Miami Harbor Federal navigation project in order to stabilize the eroding shoreline.

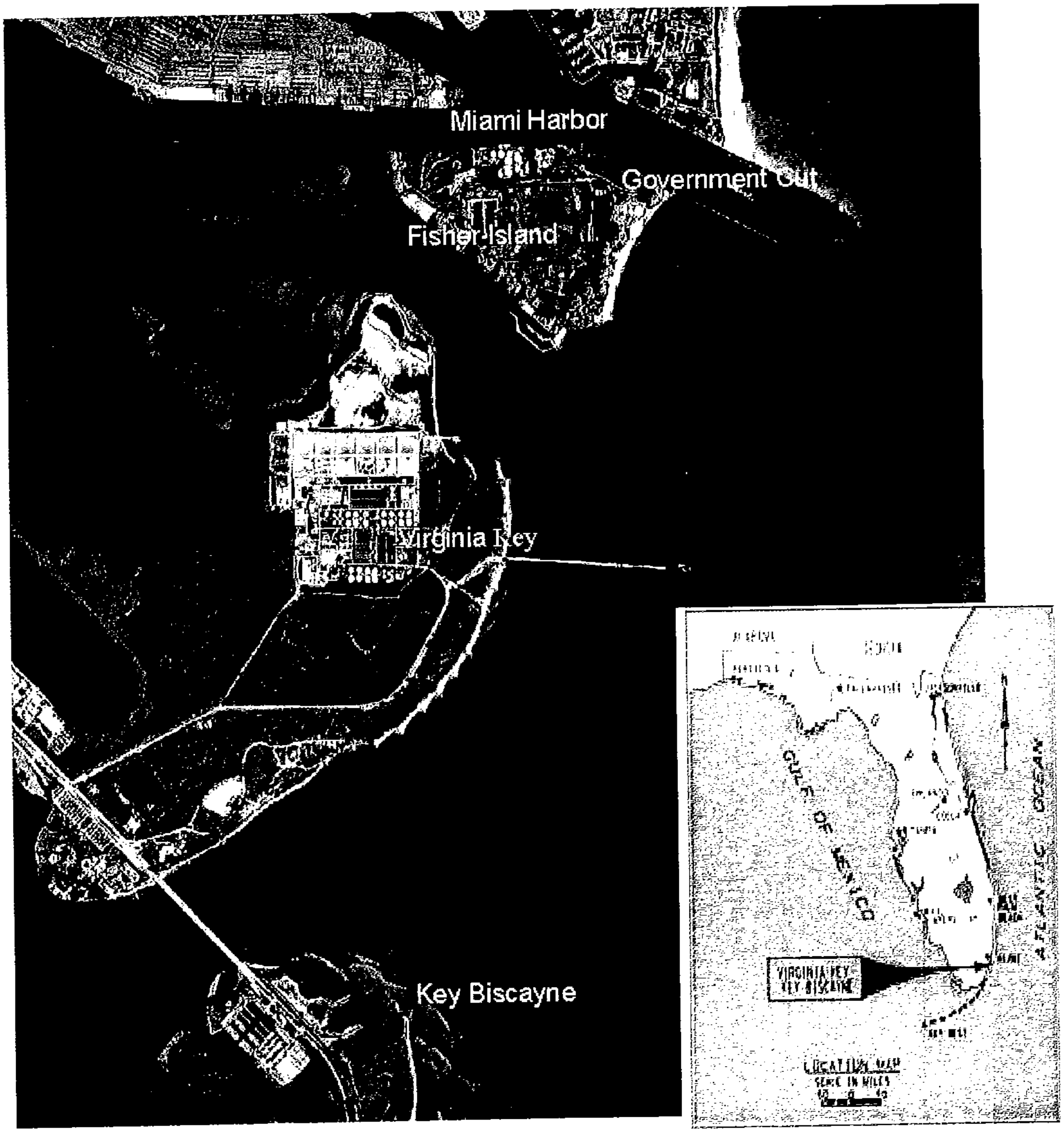
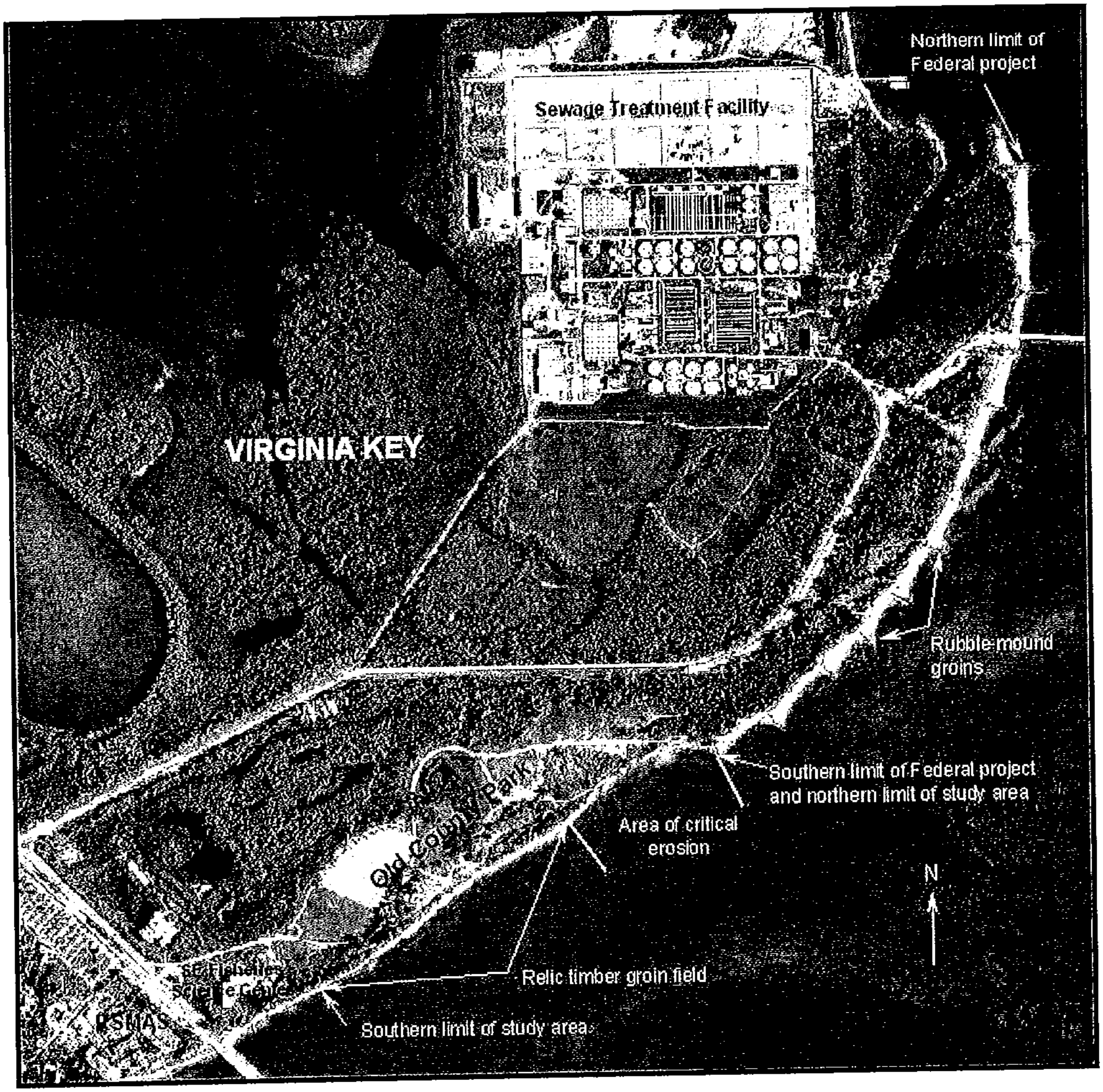


Figure 1. Project Area Map

FIGURE 2. STUDY AREA



1.5 RELATED ENVIRONMENTAL DOCUMENTS.

The following is a list of related documents:

a. Final Environmental Impact Statement, Virginia Key Beach Erosion Control Project, Second Periodic Nourishment and Groins. U.S. Army Corps of Engineers, Jacksonville District, October 1973.

b. Dade County Beaches, Florida, Beach Erosion Control and Hurricane Surge Protection, General Design Memorandum, Phase I. U.S. Army Corps of Engineers, Jacksonville District, 1974.

c. Final Environmental Impact Statement, Beach Erosion Control and Hurricane Surge Protection Project, Dade County, Florida. U.S. Army Corps of Engineers, Jacksonville District, April 1975.

d. Beach Erosion Control and Hurricane Protection Study for Dade County, Florida, North of Haulover Beach Park, Survey Report and EIS Supplement. U.S. Army Corps of Engineers, Jacksonville District, June 1984.

e. Final Environmental Assessment, Second Periodic Nourishment, Sunny Isles and Miami Beach Segments, Beach Erosion Control and Hurricane Protection Project, Dade County, Florida. U.S. Army Corps of Engineers, Jacksonville District, May 1995.

f. Coast of Florida Erosion and Storm Effects Study, Region III, Feasibility Report with Final Environmental Impact Statement. U.S. Army Corps of Engineers, Jacksonville District, October 1996.

g. Final Environmental Assessment, Beach Erosion Control and Hurricane Protection Project Dade County, Florida, Second Periodic Nourishment, Surfside and South Miami Beach Segments. U.S. Army Corps of Engineers, Jacksonville District, April 1997.

h. Final Environmental Impact Statement, Beach Erosion Control and Hurricane Protection Project Dade County, Florida, Modifications at Sunny Isles. U.S. Army Corps of Engineers, Jacksonville District, April 1998.

i. Dade County, Florida, Shore Protection Project, Design Memorandum, Addendum III, North of Haulover Park (Sunny Isles) Segment, U.S. Army Corps of Engineers, Jacksonville District, January 1995.

1.6 DECISIONS TO BE MADE.

This Environmental Assessment will evaluate whether to provide shore protection measures to Virginia Key and, if so, evaluate alternatives to accomplish that goal.

1.7 SCOPING AND ISSUES.

Scoping for the proposed project was initiated during the reconnaissance phase by a letter dated July 24, 2000. A second scoping letter was issued on January 29, 2001 for the feasibility phase of the study. The scoping letters were distribute to the appropriate Federal, State, and local agencies, appropriate city and county officials, and other parties known to be interested in the proposed project. Copies of the scoping letters, the lists used to distribute the letters, and letters of response are included in Appendix C, Pertinent Correspondence.

1.7.1 ISSUES EVALUATED IN DETAIL.

The following issues were identified be relevant to the proposed action and appropriate for detailed evaluation:

a. Turbidity and sedimentation impacts to nearshore seagrass communities.
b. Monitoring of seagrass for turbidity and sedimentation impacts.
c. Impacts on nesting sea turtles, nests, and hatchlings.
d. Mitigation.
e. Impacts on historic properties (i.e. historic shipwrecks).
f. Water quality.
g. Recreation.
h. Endangered species.
i. Affects on Johnson's seagrass.
j. Essential Fish Habitat (EFH).
k. Affects on hard coral.

1.7.2 IMPACT MEASUREMENT.

Bases for impact measurement and comparison are stated more specifically in Section 4.0 on ENVIRONMENTAL EFFECTS and other sections of this document an its appendices.

1.7.3 ISSUES ELIMINATED FROM DETAIL ANALYSIS.

No issues were specifically identified for elimination

1.8 PERMITS, LICENSES, AND ENTITLEMENTS.

The proposed action is subject to the Coastal Zone Management Act. Consultation with the State Historic Preservation Officer is also required. Since there would be a discharge of dredged or fill material into waters of the United States, the proposed Action is subject to Section 404 of the Clean Water Act. In addition the proposed action is subject to Section 401 of the Act for certification of water quality by the state. The U.S. Army Corps of Engineers, Jacksonville District, is preparing an application for a Section 401 Water Quality Certificate (WQC) from Florida Department of Environmental Protection (FDEP).

If conducted during the sea turtle nesting and hatching season, the proposed action will require daily sea turtle nest surveys and nest relocations. A permit from the Florida Fish and Wildlife Conservation Commission (FWC) to handle sea turtles and relocate nests will be required for the person(s) performing the surveys and nest relocations associated with the proposed action.

The City of Miami is the project sponsor, and is responsible for obtaining any real estate easements and rights of way required for this project.

2 ALTERNATIVES

The alternatives section is the heart of this EA. This section describes in detail the no-action alternative, the proposed action, and other reasonable alternatives that were studied in detail. Then based on the information and analysis presented in the sections on the Affected Environment and the Probable Impacts, this section presents the beneficial and adverse environmental effects of all alternatives in comparative form, providing a clear basis for choice among the options for the decisionmaker and the public.

2.1 DESCRIPTION OF INITIAL ALTERNATIVES.

Five alternatives were considered for initial evaluation:

a. Alternative 1: Without project or No-Action.

b. Alternative 2: Beach fill only.

c. Alternative 3: Remove existing timber groins and extend the federal project by constructing rock groins the entire length of the shoreline and beach fill.

d. Alternative 4: Remove all existing timber groins and replace with similar structures and beach fill. Construct a single 440-foot long groin (breakwater) parallel to the shoreline.

e. Alternative 5: Remove existing timber groins and replace with similar structures and beach fill. Construct 3 new timber groins in critical erosion area with beach fill.

2.2 ISSUES AND BASIS FOR CHOICE

The alternative plans were evaluated based on analysis of historic shoreline trends, numerical coastal modeling, ability to stabilize the shoreline, cost of construction, effects on cross-shore and longshore velocities near the shoreline, and effects on the environment. The no-action alternative is carried throughout the plan formulation for the purpose of comparing the effects of other alternatives.

2.3 ALTERNATIVES ELIMINATED FROM DETAILED EVALUATION

Based on the evaluation criteria, two of the initial alternatives were eliminated from further evaluation. The alternatives eliminated were Alternatives 2 and 4.

2.3.1 ALTERNATIVE 2.

Alternative 2 consisted of the placing of beach fill without stabilizing structures along the 1,300 feet of critically eroded shoreline. This alternative was eliminated due to several factors. Beach fill without protective structures may contribute to a much more rapid rate of erosion of the unprotected beach. Beach fills generally tend to experience high initial losses following construction due to fill stabilization. Material lost from the beach face as the front slope stabilizes, and large volumes of sand can be lost from either end of the fill due to end (diffusion) losses, if not contained by some means. While beach fill serves to address the northern eroded area, the southern timber groin system will continue to deteriorate further, eventually leading to continued erosion of the shoreline in that area. Therefore, this alternative was eliminated.

2.3.2 ALTERNATIVE 4.

Alternative 4 consisted of removing and replacing the existing timber groins, placing beach fill as needed along the project shoreline and constructing a 440-foot long breakwater offshore of the critically eroded area. This alternative was eliminated due to environmental concerns as well as concerns over tidal currents. Offshore breakwaters would reduce shoreline erosion by reducing the amount of wave energy reaching the beach, thereby reducing littoral transport. However, several problems exist with the construction of this alternative. First, numerical modeling as well field observations indicate that tidal currents through Bear Cut May be responsible for a portion of the sediment movement along this shoreline. The study area is well inside Bear Cut, and is protected from deepwater ocean waves by the 2-mile wide continental shelf, the extensive shallow sandbars of the Bear Cut ebb shoal, and by the protection provided by Virginia Key and Key Biscayne from northerly and southerly waves respectively.

Constructing an offshore breakwater would have little effect on these tidal currents, and may even amplify, to a minor degree, the current velocities along the shoreline depending on the breakwater location and orientation. A more serious problem is the presence of extensive seagrass beds along the Virginia Key shoreline. Seagrass beds exist throughout the nearshore zone within the study area, including the site considered for the location of the breakwater. Constructing a breakwater in this area would impact a large area of seagrass. In addition, an offshore breakwater could serve as a barrier, preventing sea turtles from accessing the beach to nest and hindering hatchlings from reaching the open ocean. Therefore, Alternative 4 was eliminated from further consideration.

2.4 ALTERNATIVES CONSIDERED FOR DETAIL EVALUATION

Initial alternatives 1, 3 and 5 were retained for further evaluation. For the following discussion alternatives 3 and 5 have been renamed as Structural Plan 1 (Alternative 3) and Structural Plan 2 (Alternative 5).

2.4.1 NO-ACTION PLAN (ALTERNATIVE 1).

Under the no-action alternative, no stabilizing structures or beach fill would be provided, and the shoreline within the Old County Park would be allowed to continue to erode. The minimal beach widths, which currently exist along the park, would be reduced further, making the beach unsuitable for recreation. Erosion would be the most severe along the 1,300-foot reach of shoreline between the timber groin field and the Federal rubble-mound groins and further recession into the upland vegetation would occur. The condition of the timber groins would deteriorate further, rendering these structures totally ineffective in stabilizing that portion of the park's shoreline.

2.4.2 STRUCTURAL PLAN 1 (ALTERNATIVE 3).

The existing Federally constructed rubble-mound groin field has proven to be very effective at stabilizing the shoreline on the east side of Virginia Key. Prior to constructing the groin field, this area experienced very high erosion rates. After constructing the groin field the shoreline has stabilized to the point that no further renourishments have been required. This alternative consists of removing all existing timber groins and constructing eight rubble-mound groins along the entire 3,400-foot length of the Old County Park. The new groin field would then be backfilled to stabilize the shoreline and to prevent downdrift erosion.

The eight new groins would be constructed using a rubble-mound design similar to the structures already in place along the Federal project. Each structure would be approximately 175 feet and spaced about 425 apart starting from the south end of the Federal project. The groins would be oriented perpendicular to shore and each groin would extend landward to about 10 feet past the existing escarpment and/or vegetation line to prevent breaching around the landward end of the structure. The seaward end of each structure would extend into the seagrass beds. The crest elevation of the new structures would be +5 feet, mlw, which provides a transition between the existing crest elevations of +6.5 feet for the Federal rubble-mound groins and the +4.0-foot crest elevation of the existing timber groins. This lower crest elevation was used along the park due to the greater degree of wave sheltering in this area. The median armor stone size is 1200 lbs, with side slopes of 1 vertical to 2 horizontal. To decrease the permeability of the structures a core layer would be provided consisting of 100-lb stone, with a crest elevation of +1 foot, mlw. The bedding layer would be 1 foot thick, with a bottom elevation of –2 feet, mlw. Geotextile fabric would be placed under the full width of the bedding layer. Each of the stone layers would be constructed using locally mined limerock, with a density of not less than 145 pounds per cubic foot (pcf).

Each shoreline cell between the eight new groins would be backfilled with beach compatible material following groin construction. Fill would be placed in a variable berm-width configuration to approximate the equilibrium shape of the beach, based on the shape of the existing pocket beaches between the existing rubble-mound groins. By designing the beach to approximate the equilibrium shape of the beach, the volume of sediment transport following construction can be greatly reduced. This would minimize erosional losses from the project decreasing the risk of covering additional areas of the nearshore seagrass. The design berm elevation of the beach fill is +6.0 feet mlw which corresponds to the berm elevation of the original Federal project and to the existing upland elevations along the fill area. The design beach slope would be 1 vertical on 10 horizontal. The total volume of material required to construct the beach fill is approximately 30,500 cubic yards. Following completion of the beach fill, a small dune feature would be constructed along the landward edge of the berm along the eastern portion of the park. The dune would be 2 feet high with a 2-foot crest width and 1v:10h side slopes. The dune would be constructed in five 150-foot segments (930 feet overall) with 20-foot gaps between segments for beach access. Approximately 710 cubic yards of sand would be required to construct the dune.

A potential disadvantage of using the rubble-mound groin design is the large footprint of the structures. This design results in a foundation width of 44 feet. Since the eight groins would extend a total of 842 feet into the seagrass beds, an area of 37,050 square feet of seagrass of would be covered by the structures. Placing the proposed beach fill would cover an additional 122,140 square feet of seagrass. With this alternative it is estimated that a total of 159,190 square feet or 3.65 acres of seagrass would be impacted.

2.4.3 STRUCTURAL PLAN 2 (ALTERNATIVE 5).

This alternative proposes the use of timber-pile groins as an alternative to the rubble-mound construction described in Structural Plan 1 (Alternative 3). The existing timber groin field has been in place since the 1940's and 1950's with very little shoreline erosion occurring along this area during that time. Similar to the methodology used above for the design of the rubble-mound structures, this alternative will be based heavily on duplicating and restoring the successful design of the existing timber groin field along the entire length of the park. The existing timber groins vary in length from 30 to 80 feet, and most of them are spaced 100 feet apart. Restoring the timber groins would involve removing the existing old structures and building new timber groins using the same design as for the original construction. The only modification to this plan would be to shorten several structures that extend into the seagrass beds. The portions of the timber groins that now extend into the seagrass are so badly deteriorated that they are ineffective. It was determined, based on a recent site visit, that shortening these groins to remain clear of the seagrasses would have no effect on the stability of the beach due to the close spacing these structures.

This alternative involves removing 25 existing timber groins within the limits of the park and replacing them with 25 new timber groins. In addition, new groins would be constructed at the east end of the park to stabilize the shoreline along the 1300-foot gap between the existing groin fields. The shoreline within this area is badly eroded, and currently forms a shallow embayment in which the shoreline has receded as much as 175 feet, as shown in figure 2. Several combinations of groin spacings and lengths were tested along this embayment in order to provide maximum shoreline stability and a minimum of seagrass coverage.

The lengths of the structures were designed based on the pattern of sediment accumulation along the adjacent groin fields. It was assumed that sediment would stabilize under the influences of waves and currents into the same general plan-view shapes observed in these adjacent groin fields. It was further assumed that sediment would bypass around the seaward edge of each groin in a 10-foot wide band, based on observations at the existing timber groins. During February 2001 personnel from the Miami-Dade County Department of Environmental Resources Management (DERM) delineated the landward edge of the nearshore seagrass beds. In order to determine the design lengths of each groin, CADD software was used to overlay the DERM seagrass delineation onto a recent project aerial photograph. Groins of varying lengths were then overlaid onto this aerial photograph with corresponding stabilized beach fill configurations, in order to determine the lengths of structures required to maintain a stable shoreline. Where possible, a minimum distance of 10 feet was maintained between the end of the groins and the landward edge of the seagrass bed, to reduce the environmental impacts due to sediment bypassing around the structures.

The optimum layout of the new structures from this analysis consisted of three timber groins. Spaced roughly at third-points (325 feet) along this 1,300-foot embayment. This spacing provides a smooth transition between the 425-foot spacing of the existing rubble-mound groins and the 100-foot spacing of the existing timber groins. The groin locations also correspond to natural gaps in the seagrass bed, thus minimizing seagrass impacts. The groins are designated alphabetically from east to west, and are described as follows:

Groin "A" is located 350 feet westward from the westernmost rubble-mound groin and is 100 feet in length. The seaward tip of the structure is approximately 25 feet landward of the edge of the seagrass bed.

Groin "B" is located 285 feet west of groin "A", and is 120 feet in length. This structure is slightly longer due to its location in the center of the embayment. The seaward tip of the structure is approximately 29 feet landward of the edge of seagrass.

Groin "C" is located 325 feet west of groin "B", and in 130 feet in length. This groin was placed in this position to minimize seagrass impacts, but the structure still extends about 35 feet into the seagrass bed. The distance from "C" to the easternmost existing timber-pile groin is about 340 feet.

This alternative also requires placing beach fill along the severely eroded eastern 1,300 feet of the park. Unlike the rubble-mound alternative, the relatively short lengths of these groins should minimize any downdrift erosion, so no fill placement is expected to be necessary along the length of the existing timber groin field.

Adequate berm widths currently exist along the length of the existing groin timber groin field, and due to the proximity of the seagrass beds no fill can be placed along this area without impacting seagrasses. The landward edge of the seagrass beds is located further offshore along the eastern 1,300 feet of the park. The beach fill configuration in this area was designed to minimize impacts to the nearshore seagrass beds while still maintaining adequate beach widths for storm damage protection and recreation.

The beach fill would be placed in a variable berm-width configuration. This would approximate the equilibrium shape of the beach, based on the shape of the existing pocket beaches between the rubble-mound and timber-pile groins. By designing the beach fill to approximate the equilibrium shape of the beach, the volume of sediment transport following construction can be reduced greatly, minimizing erosional losses from the project and decreasing the risk of covering additional areas of the nearshore seagrass beds. The design berm elevation of +6.0 feet mlw corresponds to the originally authorized Federal project berm elevation, and also corresponds to existing upland elevations along the fill area. The design beach slope is 1v:10h. Approximately

8,050 cubic yards of sand would be required to construct the proposed beach fill. The same dune feature described previously for alternative 3 would be constructed along the landward edge of the constructed beach berm. Constructing the dune would require an additional 710 cubic yards of fill material.

With this alternative, placing beach fill in the 1,300-foot severely eroded area of shoreline would cover approximately 7,440 square feet of seagrass. Constructing the three new timber groins would impact approximately 350 square feet of seagrass and removing the existing timber groins would impact a maximum of 500 square feet. The total amount of seagrass impact for Structural Plan 2 (Alternative 5) is estimated at 8300 square feet or 0.19 aces.

2.5 PREFERRED ALTERNATIVE

Structural Plan 2 (Alternative 5) was chosen as the recommended plan. This plan will stabilize the shoreline at Virginia Key at the lowest cost, with the least environmental impact. The timber groin design will also blend in aesthetically and restore the appearance of the historical groin field, which was originally constructed along the Old County Park. Numerical modeling has demonstrated that constructing this alternative will provide no significant changes to current velocities and patterns along the project shoreline.

The selected plan consists of four main elements, including the construction of three new timber groins along the eastern 1,300 feet of the park, the removal and reconstruction of the existing 25 timber groins, placement of a beach fill along the eroded eastern portion of the park and construction of a dune feature (refer to figures 3 and 4). The three new timber groins would total 330 linear feet in length and would be similar in design to the historic timber groins along the park. The existing groin field within the park consists of 25 structures totaling 1222 linear feet, comprised of 1030 linear feet of timber structure and 192 feet of concrete king pile structure. These structures would be completely removed and the timber portions disposed of off-site, and each of these 25 groins would be partially or totally rebuilt. A total of approximately 1190 linear feet of timber groins would be rebuilt, since 13 of the 25 groins will be shortened in order to avoid impacting the nearshore seagrass beds. The 26 concrete king piles, representing 192 linear feet of structure, would be removed and stockpiled on-site, and the timber panels between the piles will be disposed of off-site. Prior to placing the beach fill, all of the debris (including downed trees, stumps, logs, trash) would be removed from the 1,300-foot beach fill area. Then approximately 8,050 cubic yards of sand would be placed mechanically along this reach of eroded shoreline in a variable berm-width configuration. In addition, a small dune feature would be constructed along the landward edge of the berm along the eastern portion of the park. The dune would be 2 feet high with a 2-foot crest width and 1v:10h side slopes. The dune would be constructed in five 150-foot segments (930 feet overall) with 20-foot gaps between segments for beach access. Approximately 710 cubic yards of sand would be required to construct the dune. The total area of seagrass coverage would be 7,440 square feet for beach fill placement, and 350 square feet for new timber groin construction, plus a maximum of 500 square feet for king pile extraction.

The primary source of material for the beach fill construction is a sand mound located adjacent to the fill area (refer to figure 3, sand mound #2). A secondary, smaller sand mound (sand mound #1, figure 3) is located adjacent to the shoreline at the western edge of the park. Both sand mounds are stockpiles of material excavated from Key Biscayne. The sand was stored on Virginia Key as a potential source of material for beach nourishment. The primary borrow area contains approximately 60,000 cubic yards of material, and the secondary borrow area contains approximately 12,000 cubic yards of material, several times the volume required for construction of this project.

The material proposed for use as beach fill is generally light tan to tan, poorly graded quartz and carbonate sand with a trace of silt. The composite mean grain size of the sand in mound #1 is 0.29mm with an average silt content of 7.6 percent. The composite mean grain size of the sand in mound #2 is 0.34mm with an average silt content of 7.2 percent. The silt content of the proposed sand source is below the guideline established by the Florida Department of Environmental Protection of less than 10 percent passing the 230 sieve.

Because of similarities in the characteristics between proposed borrow material and the existing beach sediment, it was assumed that the beach fill would stabilize at a 1v:10h front slope, based on an analysis of existing front slopes along the park. Since the beach fill will be placed mechanically, the front slope can be constructed at this equilibrium slope of 1v:10h, and minimal slope adjustment should occur.

Due to the close proximity of the of the nearshore seagrass beds adjacent to the beach fill area, the beach fill will be moved using mechanical means such as front-end loaders, dump trucks, and/or bulldozers. Hydraulic placement of fill would not be allowed due to the adverse impacts on seagrass beds from the high turbidity levels, which would be created by the outflow of the dredge slurry. Due to the configuration of the beach fill in the cells between the new groins, the order of construction is to complete the three new timber groins before beach placement begins. The contractor may opt for partial placement of the beach fill as a means to access the seaward portions of each groin during the initial phases of construction. In this case sand 'ramps' would be constructed along each groin alignment to allow construction equipment access to the groin construction sites. All fill placed in this manner would be required to remain within the allowable beach fill templates.

2.6 ALTERNATIVES NOT WITHIN JURISDICTION OF LEAD AGENCY

To the Corp's knowledge, there are no alternatives that are not within the jurisdiction of the lead agency.

2.7 COMPARISON OF ALTERNATIVES

Table 1 lists alternatives considered and summarizes the major features and consequences of the proposed action and alternatives. See section 4.0 Environmental Effects for a more detailed discussion of impacts of alternatives.

2.8 MITIGATION

The recommended plan is the alternative that affects the least amount of seagrass and still meets the objectives of the project. The project has been designed to avoid and minimize the impacts to adjacent seagrass beds as much as practicable. However, it is estimated that approximately 0.19 acres of seagrass would be unavoidably impacted by construction. This impact is expected to be temporary and over time the seagrass would recolonize the areas disturbed during the removal the timber groins and covered by beach fill. The Corps proposes to mitigate for the temporal loss of 0.19 acres of seagrass. A mitigation plan would be developed in coordination with the Florida Department of Environmental Protection, Dade County Department of Environmental Resources Management, National Marine Fisheries Service and the U.S. Fish and Wildlife Service.

Turbidity curtains will be used where appropriate and feasible to reduce turbidity during construction. Section 4.22 Environmental Commitments, discusses other procedures that will be implemented to avoid or minimize potentially adverse environmental impacts.

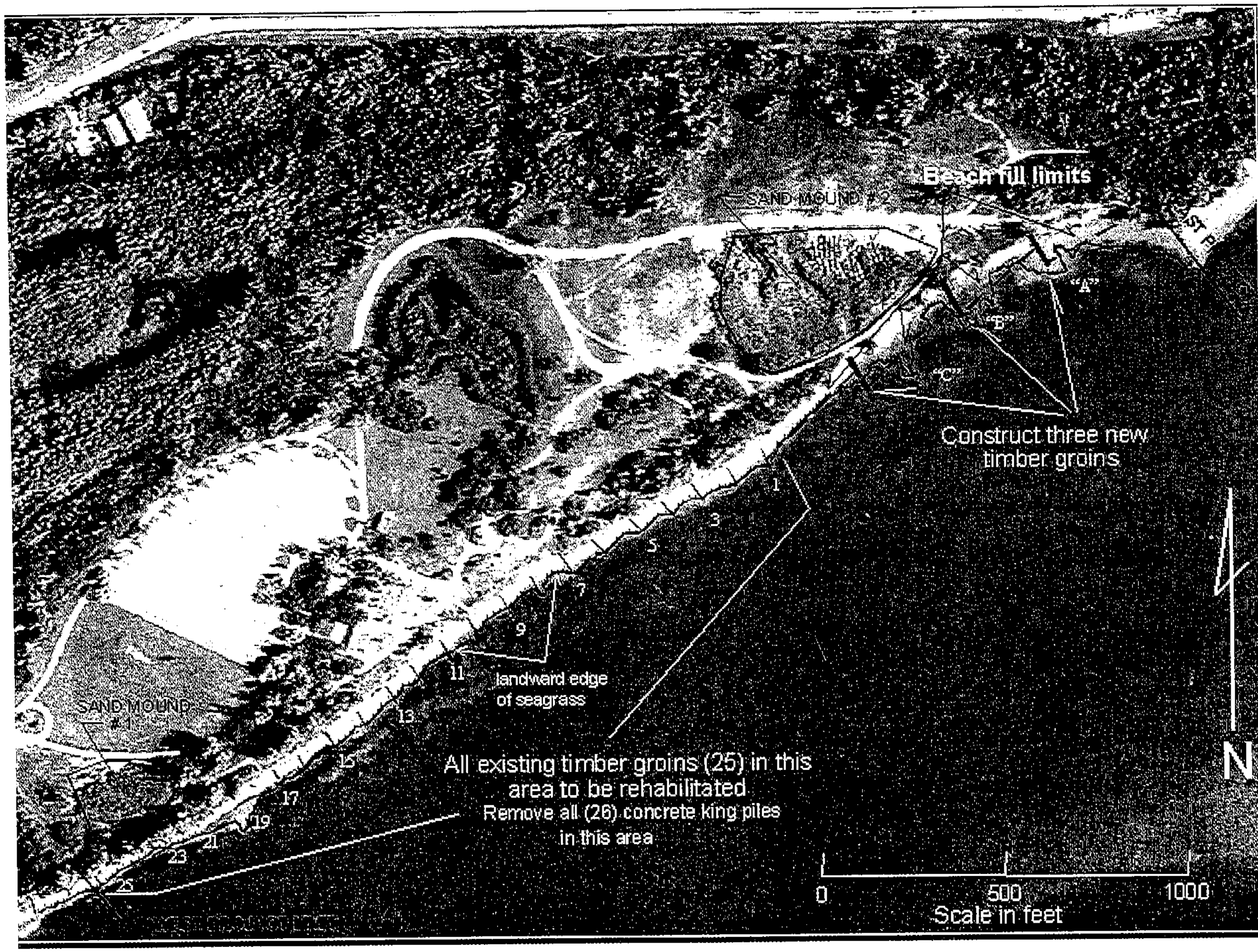


Figure 3. Recommended Plan

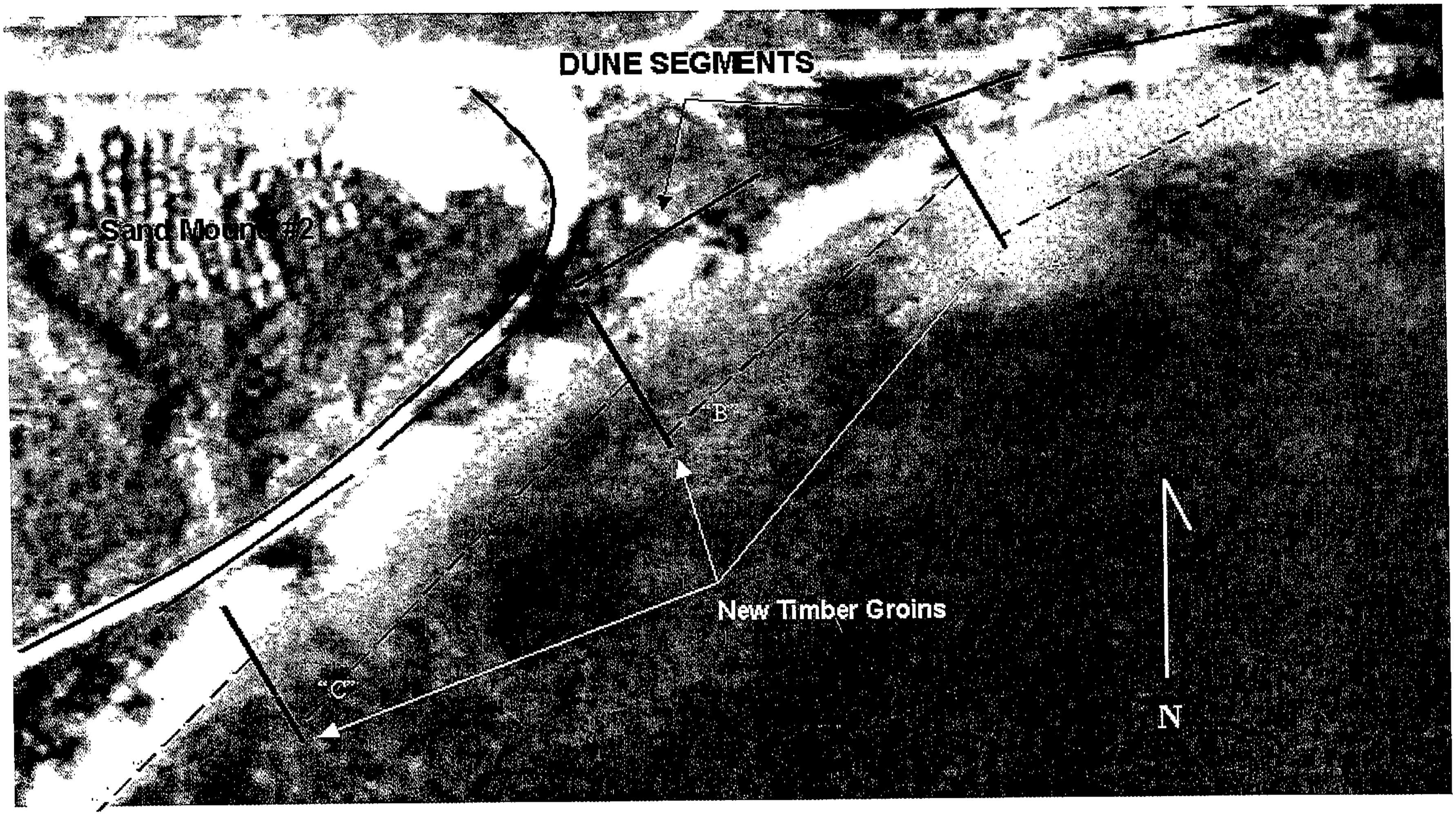


Figure 4. Location of Dune Feature

Table 1: Summary of Direct and Indirect Impacts for Alternative Plans Considered.

ALTERNATIVE ENVIRONMENTAL FACTOR	No-Action Plan (Alternative 1)	Structural Plan 1 (Alternative 3)	Structural Plan 2 (Alternative 5) This is also the Recommended Plan
PROTECTED SPECIES	Continued erosion could affect sea turtle nesting habitat and protected dune plant species.	No impact on manatees, whales or the American crocodile. Construction activities could impact sea turtle nesting or hatching if performed during the nesting season. Constructed rock groins could interfere with emerging nesting females or hatchlings heading for the ocean.	No impact on manatees, whales or the American crocodile. Construction activities could impact sea turtle nesting or hatching if performed during the nesting season. Constructed groins could interfere with emerging nesting females or hatchlings heading for the ocean.
HARDBOTTOM	No impact.	No hardbottom communities exist adjacent to the project area. No impacts to hardbottom communities would be anticipated.	No hardbottom communities exist adjacent to the project area. No impacts to hardbottom communities would be anticipated.
VEGETATION	No impact to nearshore seagrasses. Continued erosion of beach could impact upland and dune vegetation.	Beach fill would bury approximately 11,347 m^2 (122,140 ft^2) of nearshore seagrass. Construction of rubble-mound groins would cover approximately 3442 m^2 (37,050 ft^2) of seagrass.	Beach fill would bury approximately 691 m^2 (7,440 ft^2) of nearshore seagrass. Construction of rubble-mound groins would cover approximately 33 m^2 (350 ft^2) of seagrass. Removal of the old timber groins would disturb approximately 47m^2 (500 ft^2) of seagrass.
FISH AND WILDLIFE RESOURCES	Continued loss of beach habitat.	Temporary effect on benthic organisms at construction site.	Temporary effect on benthic organisms at construction site.
ESSENTIAL FISH HABITAT	No impact.	See impacts to vegetation and hardbottom above.	See impacts to vegetation and hardbottom above.
SHORELINE EROSION	Shoreline would continue to erode.	The beach would be restored and the shoreline stabilized.	The beach would be restored and the shoreline stabilized.
WATER QUALITY	No impact.	Temporary increases in turbidity and suspended sediments during groin removal and construction and placement of beach fill.	Temporary increases in turbidity and suspended sediments during groin removal and construction and placement of beach fill.
HISTORIC PROPERTIES	Continued erosion could potentially affect eligible historic properties within the Old County Park.	Replacing timber groins with rock groins would diminish the historical character of the beach.	Restoration of the timber groins will not effect historic property. The beach restoration will restore the beach to conditions similar to the historic character and will be a beneficial effect.

ALTERNATIVE ENVIRONMENTAL FACTOR	**No-Action Plan** **(Alternative 1)**	**Structural Plan 1** **(Alternative 3)**	**Structural Plan 2** **(Alternative 5)** **This is also the Recommended Plan**
RECREATION	If no-action were taken to restore the shoreline, then it would be unlikely that the city would reopen the beach at the Old County Park for recreation.	The beach at the Old County Park would be restored and stabilized and suitable for recreation.	The beach at the Old County Park would be restored and stabilized and suitable for recreation.

Table 1 (Continued): Summary of Direct and Indirect Impacts for Alternative Plans Considered.

3 AFFECTED ENVIRONMENT

The Affected Environment section succinctly describes the existing environmental resources of the areas that would be affected if any of the alternatives were implemented. This section describes only those environmental resources that are relevant to the decision to be made. It does not describe the entire existing environment, but only those environmental resources that would affect or that would be affected by the alternatives if they were implemented. This section, in conjunction with the description of the "no-action" alternative forms the base line conditions for determining the environmental impacts of the proposed action and reasonable alternatives.

3.1 GENERAL ENVIRONMENTAL SETTING

Virginia Key is a low, sandy barrier island approximately 1,000 acres in size that is a part of a chain of islands extending from Miami Beach south to the Florida Keys. The island located south of Fisher Island and north of Key Biscayne and bounded by the Atlantic Ocean to the east and Biscayne Bay to the west (Figure 1). Significant dredging and filling in the past, including the construction of the Rickenbacker Causeway, the dredging of the marine stadium basin and Fisherman Channel, transformed Virginia Key into its present form. The northern end of Virginia Key has also been previously used as a disposal site for harbor dredged materials associated with improvements to Government Cut and the Miami Harbor Federal navigation project. This upland disposal site is presently reserved for future disposal operations may be required for the upcoming Miami Harbor channel-deepening project.

Many areas on the island have been developed for human use such as, the Miami Sea Aquarium, the University of Miami Rosenstiel School of Marine and Atmospheric Sciences, NOAA Southeast Fisheries Science Center, a sewage treatment facility, a municipal landfill, and parks and parking lots for these areas as well as docks and buildings for several restaurants, marinas and commercial fishing operations. Existing natural areas on and adjacent to the island consist of seagrass beds, intertidal sand and mud flats, mangrove and herbaceous wetlands, beach dune communities, coastal strand and tropical hardwood hammock. Of the remaining vegetated areas on the island most are infested, to varying degrees, with noxious exotic vegetation.

Virginia Key has approximately 2.55 miles of shoreline facing the Atlantic Ocean, which historically has been subject to severe erosion. This has required the construction of structures to stabilize the beach. A relic timber-pile groin field exists along the southern 2,100 feet of the study area in the vicinity of the Old County Park (figure 2). A total of 25 timber groins were constructed, some in 1948 with the remaining groins constructed in 1956. The groins range from 30 to 80 feet long and most are spaced about 100 feet apart. In 1965 Dade County extended 10 groins near the center of the groin field further seaward, using concrete king piles with timber slats. The timber groin system has deteriorated to the point where it is no longer effectively stabilizing the shoreline. Each of the 25 timber groins in the area has deteriorated to some degree with the most severe deterioration seaward of the mean low water line. Figure 4 shows the typical deteriorated condition of the timber groins.

A Federal Beach Erosion Control project for Virginia Key was authorized on October 23, 1962. The project consisted of periodic beach renourishment along 1.8 miles along the eastern side of the island including the study area along the Old County Park. The initial beach fill was completed in July 1969 when 176,800 cubic yards (cy) of material were placed along the project between DNR survey monuments R-79 and R-86. The beach fill extended along the length of the present day rubble-mound groin field, and along the eastern half of the Old County Park. In 1974, construction of the rubble mound groins was begun in response to the rapid erosion of the previous beach fill. The groin field consists of 13 rubble-mound structures constructed of locally mined limerock, which extends approximately 1 mile of shoreline from survey monument R-79 to R-84. Each of these structures, except for the northernmost groin, were designed to be porous in order to allow a degree of sediment bypassing. The groins have an average length of about 150 feet and are spaced 400 to 600 feet apart. The first renourishment of the project was completed in April 1974, when 110,000 cubic yards of material from the deepening of Miami Harbor was placed between monuments R-79 and R-84 to fill in the length of the recently completed rubble-mound groin field. The Federal project was deauthorized in 1990.

Moderate to severe shoreline erosion has occurred along the entire 3,400-foot length of the Old County Park. Berm widths along the shoreline within the timber groin field range from about 20 to 40 feet at high tide, but the most severe area of erosion occurs along a 1,300-foot reach of shoreline between the timber and rubble-mound groin fields (figure 2). No stabilizing structures exist along this reach of the study area, except for two loose piles of rocks which are apparently the relics of destroyed rubble-mound groins. Berm widths along this reach of shoreline average about 5 to 10 feet at high tide. The shoreline in this area has receded to such a point that it has resulted in the loss of trees and other and upland vegetation, exposed rubble, clay and peat layers and formed escarpments along the upper beach. Figures 5, 6 & 7 show the conditions of the shoreline in this critically eroded area of Virginia Key.

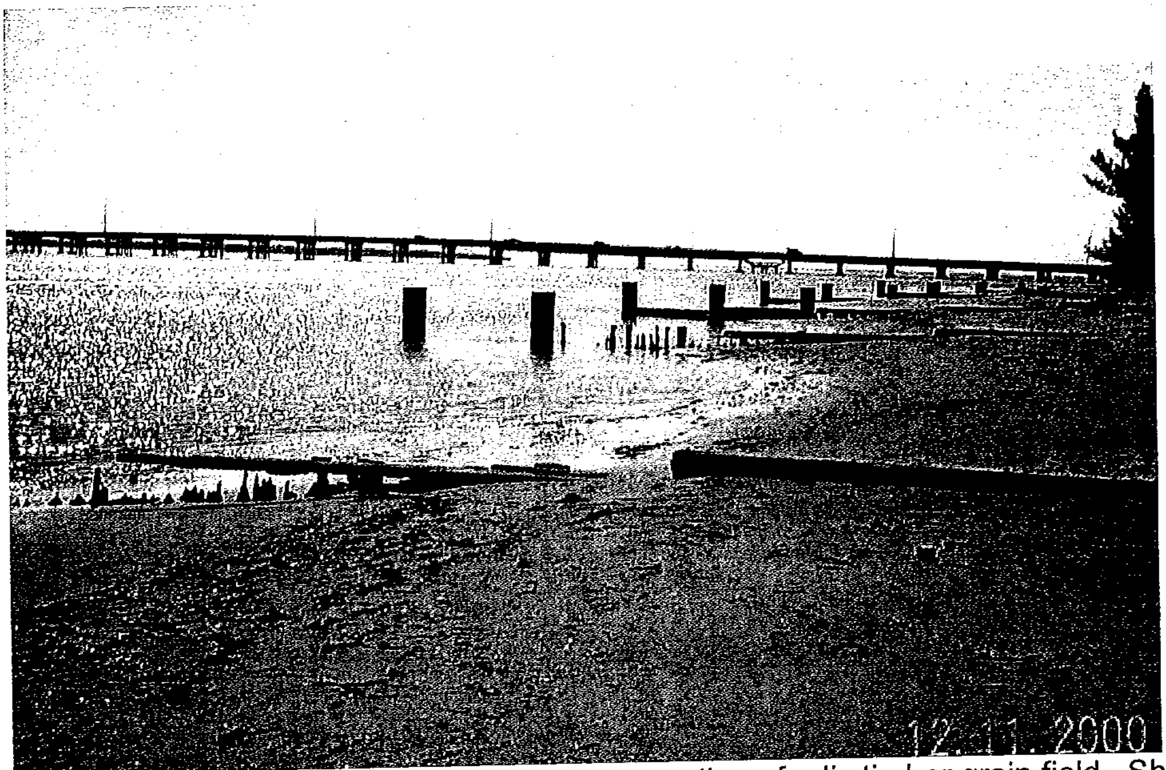


Figure 5. Looking southwest along southern portion of relic timber groin field. Shows deteriorated condition of timber groins.

FIGURE 6. Shoreline along critically eroded area showing fallen trees (Jan 2001).

Figure 7. View looking north, from the eroded area to the southern most federal rock groin, background.

Figure 8. Clay layer exposed at back beach and in scarp behind beach.

Tidal currents adjacent to the shoreline are reported at up to seven or eight knots during maximum tide conditions. The erosion along Virginia Key is reported to be attributed to the Government Cut navigation project at Miami Harbor. The jetties and bar channel of the Federal project are believed to act as a complete sediment barrier to the southward sediment transport.

3.2 THREATENED AND ENDANGERED SPECIES

3.2.1 SEA TURTLES

Sea turtles are present in Biscayne Bay and in the open ocean offshore of Dade County year-round because of warm water temperatures and seagrass and hardbottom habitat used for both foraging and shelter. The predominant species is the loggerhead sea turtle, *Caretta caretta*, although green turtles, *Chelonia mydas*; leatherback turtles, *Dermochelys coriacea*; hawksbill turtles, *Eretmochelys imbricata*; and Kemp's ridleys, *Lepidochelys kempii* are also known to exist in the area. All the sea turtles except for the loggerhead are listed as endangered. The loggerhead is listed as threatened.

The beach and dune communities within the study area do provide nesting habitat for sea turtles. The dunes within this area are small to non-existent and the beach is relatively narrow. The loggerhead, *Caretta caretta*, has been documented to nest on the beaches on Virginia Key (Meylan et. al., 1995; NMFS, 2001; FMRI, 1999) and there is one documented nesting by a hawksbill turtle in 1995 (FMRI, 1999). According to information provided by the National Marine Fisheries Service (NMFS), for the 1991-1997 nesting seasons, the vast majority of nesting occurs outside the study area within the Federal Beach Erosion Control Project north of the study area. Both the loggerhead and green, *Chelonia mydas*, are known to forage in the nearshore waters adjacent to Virginia Key. Seagrass and algae are some of the principle forage for the green turtle.

3.2.2 WEST INDIAN MANATEE

The estuarine waters around the inlets and bays within Dade County provide year-round habitat for the West Indian manatee, *Trichecus manatus*. Although manatees have been observed in the open ocean, they feed and reside mainly in the estuarine areas and around inlets. The seagrass located offshore of Virginia Key would provide foraging areas for the manatee. However, the water immediately offshore of the study area is very shallow and it would be unlikely that manatees would venture within the area of active construction.

3.2.3 JOHNSON'S SEAGRASS

Johnson's seagrass, *Halophila johnsonii*, is federally listed as a threatened species. It is only known to exist in coastal waters of southeastern Florida, from Sebastian Inlet to northern Biscayne Bay. It is most abundant in the intertidal area above and the subtidal area below where other seagrass species grow. *H. johnsonii* has not been documented within the immediate study area but has recently been found just north of Virginia Key in Norris Cut (L. Bolen, pers. com. 2001). No Johnson's seagrass was observed during a seagrass survey conducted offshore of the project area during August 2001 (Dial Cordy & Assoc., 2001).

3.2.4 OTHER THREATENED AND ENDANGERED SPECIES

Other threatened or endangered species that may be found in the in the coastal waters off of Dade County during certain times of the year are the finback whale, *Balaenoptera physalus*; humpback whale, *Megaptera novaeangliae*; right whale *Eubalaena glacialis*; sei whale, *Balaenoptera borealis*; and the sperm whale *Physeter macrocephalus catodon*. These are infrequent visitors to the area and are not likely to be impacted by project activities.

3.3 FISH AND WILDLIFE RESOURCES

3.3.1 VEGETATION

Outside of the developed areas on Virginia Key, several different plant communities exist which include dune community, coastal strand community, tropical hardwood hammock, and tidal coastal band mangrove community. Vegetation typically found within the dune community include sea oats, *Uniola paniculata*, inkberry, *Scaevola plumieri*, bay cedar, *Suriana maritima*, and salt wort, *Batis maritima*. Cabbage palm, Sabal palmetto, *Serenoa repens*, beach sunflower, *Helianthus debilis*, and cocoplum, *Chrysobalanus icaco*, are typical of the vegetation found in the coastal strand community. The tropical hardwood hammock area are typically dominated by seagrape, *Coccoloba uvifera*, with extensive strands of Spanish stopper, *Eugenia foetida*. Additional trees and shrubs present in these areas include gumbo limbo, *Bursera simaruba*, saffrom plum, *Bumelia celastrina*, strangler fig, *Ficus aurea*, torchwood, Amyris eleminfera, mahogany, *Swietenia mahogoni*, and wild coffee, *Psychotria nervosa*. The coastal band mangrove community consists primarily of red mangrove, *Rhisophora mangle*, black mangrove, *Avicennia germinans*, and bottonwood, *Conocarpus erectus*. All of these communities are infested to some greater or lesser degree with noxious exotic vegetation. The most common noxious exotics include Australian pine, *Casurina equisetifolia*, Brazillian pepper, *Shinus terebinthifolius*, and lather leaf, *Colubrina asiatica*.

The nearshore area surrounding Virginia Key is almost completely colonized by seagrass. Dense seagrass beds comprised primarily of turtle grass, *Thalassia testudinum*, manatee grass, *Syringodium filiforme*, and shoal grass, *Halodule wrightii*, can be found within ten to fifteen feet of the shoreline within the study area. In some instances, *Halodule* can be found exposed at low tide. Another seagrass species that may be present to a lesser extent is paddle grass, *Halophila decipiens*. Seagrasses are highly productive, faunally rich, and ecologically important habitat within the coastal lagoons, bays and estuaries of South Florida. The nearshore seagrasses around Virginia Key provide structure and habitat that offers refuge from predators, forage and recruitment opportunities for many of the important recreational and commercial fisheries species (e.g. shrimp, lobster, fish), as well as other invertebrates, birds and mammals. Manatees and green sea turtles feed directly on seagrass. Seagrasses are also important primary producers, converting the sun's energy into food and structure useful to fish, invertebrates, and wildlife, and sequestering carbon, producing oxygen and stabilizing the sediments with their root structure, as well as clarifying the water. During August 2001, Dial Cordy and Associates, Inc. conducted a survey to map marine seagrasses. Marine sea grasses were distributed throughout the area surveyed with *T. testudinum* and *S. filiforme* being the most abundant species. *H. wrightii* was also found in the area. The results of the survey can be found in Appendix F.

3.3.2 BEACH AND OFFSHORE SAND BOTTOM COMMUNITIES

The beaches of southeast Florida are exposed beaches and receive the full impact of wind and wave action. Intertidal sandy beaches usually have low species richness, but the species that can survive in this high-energy environment are abundant. The upper portion of the beach, or subterrestrial fringe, is dominated by various talitrid amphipods and the ghost crab *Ocypode quadrata*. In the midlittoral zone (beach face of the foreshore), polychaetes, isopods, and haustoriid amphipods become dominant forms. In the swash or surf zone, coquina clams of the genus *Donax* and the mole crab *Emerita talpoida* typically dominate the beach fauna. All these invertebrates are highly specialized for life in this type of environment (Spring, 1981; Nelson, 1985).

Shallow subtidal soft bottom habitats (0 to 1 meters [0 to 3 feet] depth) show an increasing species richness and are dominated by a relatively even mix of polychaetes (primarily spionids), gastropods (*Oliva* sp., *Terebra* sp.), portunid crabs (*Arenaeus* sp., *Callinectes* sp., *Ovalipes* sp.), and burrowing shrimp (*Callianassa* sp.). In slightly deeper water (1 to 3 meters [3 to 10 feet] depth) the fauna is dominated by polychaetes, haustoid and other amphipod groups, bivalves such as *Donax* sp. and *Tellina* sp. (Marsh *et al.*, 1980; Goldberg *et al.*, 1985; Gorzelany and Nelson, 1987; Nelson, 1985; Dodge *et al.*, 1991).

3.3.3 REEF/HARDBOTTOM COMMUNITIES

Coral reefs are best developed in the United States in south Florida along the Florida Keys. Farther north, through Miami-Dade and Broward Counties reef-building corals decline with fewer hard corals present and live bottom communities are more prevalent. Reefs in the vicinity of Virginia Key can be classified as live bottom or live rock communities with scattered hard coral. Results of the benthic survey conducted by Dial Cordy and Associates, Inc. indicate that hardbottom communities are limited mainly to scattered rubble with attached sponges and algae and occurred primarily at the southern end of Virginia Key near the causeway. No extensive hardbottom communities exist in the immediate vicinity of the proposed project area that would be affected by the project.

3.3.4 FISH

Biscayne Bay and the Atlantic Ocean waters adjacent to Virginia Key contain a large and diverse fish fauna. Both temperate and tropical species are represented. A somewhat seasonal fluctuation occurs with tropical species more prevalent in the summer and temperate species replacing them in the winter. Many of these species are dependent on mangrove, seagrasses and wetlands in the area for forage and predator avoidance areas. Some examples include the spotted seatrout, *Cynoscion nebulosus*, snook, *Cetropomus undecimalis*, red drum, *Sciaenops ocellata*, permit, *Trachinotus falcatus*, various members of the grunt (Haemulidae), snapper (Lutjanidae), and grouper (Serranidae), families and a number of prey fish.

3.3.5 INVERTEBRATES

A large number of invertebrates inhabit the bay and ocean waters surrounding Virginia Key. The mangrove, wetland and seagrass communities act as a refuge and recruitment area for many of these species. A few common species that occur in the area are sea urchins, *Lytechinus variegatus*, penaeid shrimp, *Penaeus* spp., portunid crabs, *Callinectes* spp. and *Portunus* spp., stone crab, *Menippe mercanaria*, and spiny lobster, *Panulirus argus*, are all known to frequent these areas during various life history stages.

3.3.6 BIRDS

A variety of wading birds utilize the barrier islands in the area for foraging, roosting, and nesting. The tidal wetland communities generate many of the prey species of invertebrates and fish needed for wading birds. Some examples of birds that can be found on Virginia Key include: great blue herons, *Ardea herodias*, little blue herons, *Florida caerulea*, great egrets, *Casmerodeus albus*, reddish egrets, *Dichromanassa rufescens*, brown pelican, *Pelecanus occidentalis*, osprey, *Pandion haliaetus*, wood stork, *Mycteria americana*, common flickers, *Colaptes auratus*, and red bellied woodpeckers, *Centurus carolinus*.

3.4 ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act, (MSFCMA) 16USC 1801 et seq. Public Law 104-208 reflects the Secretary of Commerce and Fishery Management Council authority and responsibilities for the protection of Essential Fish Habitat (EFH). Federal agencies that fund, permit, or carry out activities that may adversely impact EFH are required to consult with the National Marine Fisheries Service (NMFS) regarding the potential effects of their actions on EFH. In conformance with the 1996 amendment to the Act,

Pursuant to MSFCMA, the South Atlantic Fishery Management Council (SAFMC) has identified EFH that may exist in the project area for species they manage including shrimp, the snapper-grouper complex (containing ten families and 73 species), Spanish mackerel, red drum, coral and coral reef communities, and spiny lobster. The NMFS has identified EFH for highly migratory species that include billfishes and species of sharks that inhabit this area, such as nurse, blacktip, sand bar, lemon, and bull sharks. Various life stages of some managed species that may be found in the project area include larvae, postlarvae, juvenile and adult stages of red, gray, lane, schoolmaster, mutton and yellowtail snapper; scamp, speckled hind, red, yellowedge and gag groupers; Spanish and king mackerel; red drum; white grunt; and spiny lobster.

Categories of EFH that may be adversely impacted include marine water column, live/hardbottoms, coral, coral reefs and artificial/manmade reefs, seagrasses, estuarine scrub/shrub mangroves, and intertidal flats. The SAFMC has identified EFH Habitat Areas of Particular Concern (HAPC) which may occur within the project area. HAPC's are subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Offshore areas of high habitat value or vertical relief, and habitats used for migration, spawning, and rearing of fish and shellfish have been included within HAPC. Specifically, categories of HAPC that may exist within the vicinity of the proposed project include hermatypic coral habitat and reefs, hard bottom habitats, and submerged aquatic vegetation. In addition, Biscayne National Park and Biscayne Bay are adjacent to the project area and are two geographically defined HAPC's (Biscayne Bay is also designated as an Outstanding Florida Water by the Florida Fish and Wildlife Conservation Commission).

In addition to EFH for Federally managed species, hard bottom, coral, seagrass, mangrove, and shallow nearshore habitats provide nursery, foraging, and refuge habitat for other commercially and recreationally important fish and shellfish. Species such as blue crab, flounder, spotted seatrout, pompano, snook, striped mullet, tarpon, and a variety of reef fish and topical fish are among the many species that utilize these habitats.

3.5 COASTAL BARRIER RESOURCES

There are no designated Coastal Barrier Resource Act Units located in the project area that would be affected by this project.

3.6 WATER QUALITY

Waters off the coast of Dade counties are classified as Class III waters by the State of Florida. Class III category waters are suitable for recreation and the propagation of fish and wildlife. Turbidity is the major limiting factor in coastal water quality in South Florida. Turbidity is measured in Nephelometric Turbidity Units (NTU), which quantitatively measure light-scattering characteristics of the water. However, this measurement does not address the characteristics of the suspended material that creates turbid conditions. According to Dompe and Haynes (1993), the two major sources of turbidity in coastal areas are very fine organic particulate matter and sediments and sand-sized sediments that become resuspended around the seabed from local waves and currents. Florida state guidelines set to minimize turbidity impacts from beach restoration activities confine turbidity values to under 29 NTU above ambient levels outside the turbidity mixing zone for Class III waters.

Turbidity values are generally lowest in the summer months and highest in the winter months, corresponding with winter storm events and the rainy season (Dompe and Haynes, 1993; Coastal Planning & Engineering [CPE], 1989). Moreover, higher turbidity levels can generally be expected around inlet areas, and especially in estuarine areas, where nutrient and entrained sediment levels are higher. Although some colloidal material will remain suspended in the water column upon disturbance, high turbidity episodes usually return to background conditions within several days to several weeks, depending on the duration of the perturbation (storm event or other) and on the amount of suspended fines.

3.7 HAZARDOUS, TOXIC AND RADIOACTIVE WASTE

The coastline within the project area is a city park used for recreation. The areas within the project are high-energy littoral zones and the material used for nourishment is composed of particles with large grain sizes that do not normally have contaminants adsorbing to them. The Hazardous, Toxic or Radioactive Waste (HTRW) preliminary assessment indicated no evidence of HTRW. The HTRW database review indicated no HTRW related issues within the project area on Virginia Key. No contamination due to hazardous and toxic waste spills is known to be in the study area.

3.8 AIR QUALITY

Air quality within the project area is good due to the presence of either on or offshore breezes. Dade County is in attainment with the Florida State Air Quality Implementation Plan for all parameters except for the air pollutant ozone. The county is designated as a moderate non-attainment area for ozone.

3.9 NOISE

Ambient noise around the project area is typical to that experienced in recreational environments. Noise levels range from low to moderate based on the density of development and recreational usage. The major noise producing sources include breaking surf, beach and nearshore water activities, and boat and vehicular traffic. These sources are expected to remain at their present noise levels.

3.10 AESTHETIC RESOURCES

The existing beach has within the project area is severely eroded and in one section has uprooted trees and exposed rock rubble and layers of clay and peat making the area unusable for recreation.

3.11 RECREATION RESOURCES

The City of Miami owns most of Virginia Key, including the proposed project area, as a result of a land deed transfer from Dade County in 1982. The Virginia Key beachfront is the only oceanfront shoreline within the city limits. This beachfront property includes the North Beach Park, which opened to the public in the 1970's and the Old County Park which was closed to the public in 1982.

3.12 HISTORIC PROPERTIES

One of the earliest recorded historic events associated with Virginia Key is documented in 1838, when three Seminoles were killed by US Navy gunfire at a place along Bear Cut. The modern history of Virginia Key is tied directly into the development of the Virginia Key Beach Park. By 1920, as the city of Miami grew, many of the county's beaches were developed into parks and public swimming facilities exclusively for the white population. There were unofficial areas though where the black community could go to enjoy the area's beaches. One place was Virginia Key, which was popularly known as Bear's Cut. In August 1, 1945, Virginia Beach was officially opened as "a Dade County Park for the exclusive use of Negroes". Virginia Key Beach quickly became a popular recreation area with a boat ramp, mini-train, bathhouse, picnic areas, a dance floor and a merry-go-round. Throughout the years of segregation in the 1940s and 1950s and integration in the early 1960s, Virginia Key Beach Park remained the preferred recreation area for many in the black community. This would continue until 1982 when Dade County conveyed several parcels of land on Virginia Key, including the 77-acre Beach Park, to the City of Miami in a land swap. Shortly after the transfer, however, the City of Miami closed the Park.

Virginia Key Beach Park has been nominated to the National Register of Historic Places based on its association with segregation and the Civil Rights Movement. Many of the Park's original buildings are still extant. A cultural resource survey has been conducted for the park and no historic property other than the historic park was identified (Ransom et al. 2001).

4 ENVIRONMENTAL EFFECTS

This section is the scientific and analytic basis for the comparisons of the alternatives. See table 1 in section 2.0 Alternatives, for summary of impacts. The following includes anticipated changes to the existing environment including direct, indirect, and cumulative effects.

4.1 GENERAL ENVIRONMENTAL EFFECTS

Implementing the proposed action would restore some of the beach's ability to provide protection against storms and flooding. It would also enhance the appearance and suitability for recreation at the Old County Park and would provide additional nesting habitat for threatened and endangered species of sea turtles. Removal of the existing deteriorated timber groins would disturb some seagrass adjacent to the structures. Seagrass would also be impacted by placing beach fill along the eastern 1,300 feet of the project area and by construction of one of the timber groins. Any impacts to seagrasses will be appropriately mitigated.

4.2 THREATENED AND ENDANGERED SPECIES

4.2.1 NO ACTION PLAN (ALTERNATIVE 1)

If no action is taken, the beach would continue to erode. If left to erode, this could ultimately result in the loss of sea turtle nesting habitat and/or poor nest site selection. No adverse impacts to other listed species are expected.

4.2.2 STRUCTURAL PLAN 1 (ALTERNATIVE 3)

Beach nourishment and associated activities have the potential to impact sea turtles and may have the following effects.

a. Scarp development leading to hindrance or blockage of accessibility to nesting habitat.

b. Adverse alteration of moisture levels or temperature in beach due to modified nesting material.

c. Compaction and cementation of beach sediments that cause reduced nesting success and aberrant nest cavity construction resulting in reduced nesting and/or hatching success.

d. If carried out during the nesting season, there is a potential for the destruction of nests that are not identified during the daily nest survey and relocation program.

e. Disruption of nesting activities that could lead to poor nest site selection and energetic cost diminishing egg production.

f. Disorientation or misorientation of hatchlings from adjacent beaches by artificial lights on construction equipment on the beach.

Important physical characteristics of beaches include sand grain size, grain shape, silt-clay content, sand color, beach hardness, moisture content, mineral content, substrate water potential, and porosity/gas diffusion. By using proper management techniques such as nest relocation, tilling of compacted beaches, use of compatible sand, and smoothing of scarp formations, most of the negative effects can be avoided or corrected (Nelson and Dickerson, 1989a).

Artificial lighting along the beach is known to affect the orientation of hatchlings (Dickerson and Nelson, 1989; Witherington, 1991) and to effect the emergence of nesting females onto the beach (Witherington, 1992). If beach nourishment activities occur at night during the sea turtle nesting and hatching season, lighting associated with construction activities on the beach may effect hatchlings and nesting females. Research has shown that low pressure sodium (LPS) lights that emit only yellow wavelengths do not attract hatchlings (Dickerson and Nelson 1989; Nelson and Dickerson, 1989b). Witherington (1992) demonstrated that LPS lights on the beach did not significantly effect the nesting behavior of green or loggerhead sea turtles. The use of LPS lighting at the beach nourishment site may reduce the potential for lighting effects on sea turtles. However, the Corps is concerned about the appropriateness of using LPS lights in a marine environment for safety reasons.

If the rubble mound groins are constructed during the sea turtle nesting season, construction activities and lighting (if construction occurs at night) would have similar affects on hatching orientation and nesting female behavior as discussed for beach nourishment activities. If constructed outside the nesting season there would be no adverse affects due to construction activities. Improperly designed and/or placed groins could potentially interfere with sea turtle nesting and hatchling emergence and egress offshore.

It is not expected that this alternative would have any adverse impacts on other listed species.

4.2.3 STRUCTURAL PLAN 2 (ALTERNATIVE 5) PROPOSED ACTION

The potential impacts to sea turtles described in Structural Plan 1 for beach nourishment activities would be the same for this alternative. However, the length of shoreline that would be affected by beach fill is 2,100 feet less than Structural Plan 1. The potential impacts to sea turtles associated from groin construction would also be the same as Structural Plan 1. This alternative is not expected to adversely impact other listed species.

4.3 FISH AND WILDLIFE RESOURCES

4.3.1 VEGETATION

4.3.1.1 No Action Plan (Alternative 1)

Alternative would have no effect on marine vegetation. However, continued erosion could result in the further loss of upland and dune vegetation adjacent to the beach.

4.3.1.2 Structural Plan 1 (Alternative 3)

Placing approximately 26,800 cubic yards of beach fill would result in covering approximately 122,140 ft^2 (11,347 m^2) or 2.8 acres of seagrass. Constructing the eight rubble-mound groins would cover approximately 37,050 ft^2 (3,442 m^2) or 0.85 acres of seagrass. The total impact to seagrass from implementing this alternative would be approximately 159,190 ft^2 (14,789 m^2) or 3.65 acres. During beach fill operations and groin construction, turbidity and sedimentation levels would be elevated within the immediate vicinity of construction. These would be temporary and would return to normal after construction. The increased turbidity and sedimentation may have some impact on the nearshore seagrasses that are not directly covered by beach fill or the rubble-mound groins.

4.3.1.3 Structural Plan 2 (Alternative 5) Proposed Action

With this alternative placing approximately 5,000 cubic yards of beach fill in the 1,300-foot eroded area of shoreline would cover approximately 7,440 ft^2 (691 m^2) of seagrass. Constructing the three new timber groins would impact approximately 350 ft^2 (33 m^2) of seagrass and removing the existing timber groins would impact a maximum of 500 ft^2 (46 m^2). The total impact to seagrass from implementing this alternative would be approximately 8,290 ft^2 (771 m^2) or 0.19 acres. There would also be some turbidity and sedimentation impacts to due to groin construction and fill placement to adjacent seagrasses not directly covered by beach fill or the rubble-mound groins. Since the beach fill material will be dry placed and not hydraulically placed, turbidity and sedimentation impacts to seagrass is expected to be minimal.

4.3.2 BEACH AND OFFSHORE SANDBOTTOM COMMUNITIES

4.3.2.1 No Action Plan (Alternative 1)

With the no action alternative, none of the impacts associated with placing sand on the beach or constructing groins would occur.

4.3.2.2 Structural Plan 1 (Alternative 3)

The disposal of sand on the beach would have temporary impacts to the macroinfaunal community. Some organisms may be buried and lost, but many organisms inhabiting the intertidal zone are well adapted for burrowing and would be able to burrow up through the fill material and survive. Turbidity levels along the disposal site would temporarily increase, but would return to normal after beach equilibrium is achieved. Dominant infaunal inhabitants of the intertidal zone, such as amphipods, isopods and polychaetes typically possess high fecundity and rapid turnover rates during their breeding season. Because of this, any losses due to construction activities would be replaced within a short time. The quality of the material that will be used for beach fill would be compatible with the existing beach. No long-term adverse effects are anticipated to the intertidal macroinfaunal community due to nourishment activities (Deis, et al. 1992, Nelson 1985, Gorzelany & Nelson 1987).

Constructing the groins would have a minor and temporary impact in the macroinfaunal community within the construction area during construction activities. These impacts would be similar to those described for the beach fill. Once constructed the area within the footprints of the groins would not be available for recolonization by benthic organisms.

4.3.2.3 Structural Plan 2 (Alternative 5) Proposed Action

The effects on beach and offshore sand bottom communities from this alternative would be similar to what was discussed for Structural Plan 1 above. However, the length of beach to be filled, volume of material to be used and area of groin footprint is considerably less with this alternative than with Structural plan 1. Therefore, the total area of sandbottom habitat impacted would be less when compared to Structural Plan 1.

4.3.3 REEF/HARDBOTTOM COMMUNITIES

4.3.3.1 No Action Plan (Alternative 1)

With the no action alternative, none of the impacts associated with placing sand on the beach or constructing groins would occur.

4.3.3.2 Structural Plan 1 (Alternative 3)

Results of the benthic survey conducted by Dial Cordy and Associates, Inc. indicate that hardbottom communities are limited mainly to scattered rubble with attached sponges and algae and occurred primarily at the southern end of Virginia Key near the causeway. No extensive hardbottom communities exist in the immediate vicinity of the proposed project area. It is not expected that any hardbottom communities would be impacted by this alternative.

4.3.3.3 Structural Plan 2 (Alternative 5) Proposed Action

As in Structural Plan 1, it is not expected that any hardbottom communities would be impacted by this alternative.

4.3.4 FISH

4.3.4.1 No Action Plan (Alternative 1)

With the no action alternative, none of the impacts associated with placing sand on the beach or constructing groins would occur.

4.3.4.2 Structural Plan 1 (Alternative 3)

Fish are a highly motile group of organisms. It is expected that during construction most fish will avoid the area and return after completion. Most surf zone fish may tolerate an elevated level of turbidity, however, burrowing fish may be at a greater risk from burial. No long-term impacts are expected to fish communities.

4.3.4.3 Structural Plan 2 (Alternative 5) Proposed Action

The potential affects to fish from this alternative would be the same as Structural Plan 1.

4.3.5 BIRDS

4.3.5.1 No Action Plan (Alternative 1)

With the no action alternative, none of the impacts associated with placing sand on the beach or constructing groins would occur.

4.3.5.2 Structural Plan 1 (Alternative 3)

During the placement of sand on the beach there may be some interruption of foraging and resting activities for shorebirds that utilize the project area. This impact would be short-term and limited to the immediate area of disposal and time of construction. There would be sufficient beach area north and south of the renourishment sites that can be used by displaced birds while construction takes place. Elevated turbidity levels within the immediate vicinity of the discharge site may interfere with foraging by sight feeders such as the brown pelican (*Pelecanus occidentalis*). However, increased turbidity levels would be limited to a small portion of the shoreline and should not result in significant impacts to foraging activities.

4.3.5.3 Structural Plan 2 (Alternative 5) Proposed Action

Potential impacts would be the same as Structural Plan 1.

4.4 ESSENTIAL FISH HABITAT

Impacts to Essential Fish Habitat from the proposed project are discussed in detail in Section 4.3 of this EA. Impacts include covering approximately 7,440 ft^2 (691m^2) of seagrass with beach fill and the loss of approximately 850 ft^2 (79 m^2) of seagrass during the removal of the existing timber groins and the construction of the new timber groins. Mitigation for any impacts to nearshore seagrasses due to project construction would be performed as part of the proposed project. A specific mitigation plan would be developed in coordination with the Florida Department of Environmental Protection, Dade County Department of Environmental Resources Management, National Marine Fisheries Service and the U.S. Fish and Wildlife Service. No impacts to hardbottom communities are expected to occur by implementing the proposed action.

There will also be temporary turbidity impacts to the water column adjacent to the project area during placement of the beach fill, removal of the old timber groins and construction of the new timber groins. To minimize the effects of turbidity and sedimentation on nearshore seagrasses the beach fill material will not be hydraulically placed but will be placed dry from land using earth-moving equipment. Turbidity is not expected to exceed the State standard of 29 NTU's above background.

4.5 HISTORIC PROPERTIES

An archival review and cultural resources survey have been conducted to locate and identify any significant prehistoric or historic properties within the area of potential effect for the proposed shore stabilization project. The Virginia Key Beach Park is the only property within the area of potential effects. The park has been nominated for inclusion in the National Register of Historic Places. The Corps has determined that the replacement of timber groins in kind will have no effect on the historic property. Additionally the Corps has determined that the project will restore the historic character of the beach and the effects will be beneficial and not adverse. In a letter dated January 10, 2002, the Corps requested the Florida State Historic Preservation Officer to concur with the determination that the project will have no adverse effect on the Virginia Key Beach Park. The SHPO concurred with that determination in a letter dated January 17, 2002.

4.6 AESTHETICS

There would be a temporary increase in the noise level during construction. The principle noise would stem from construction equipment on the beach. All construction equipment would be properly maintained to minimize the effects of noise. Increases to the current levels of noise as a result of this project would be localized and minor, and limited to the time of construction. Engine exhaust fumes would be rapidly carried away by breezes. Any temporary decrease in air quality caused by this work would be corrected once work is completed. Construction equipment and material lying on the beach would have a negative visual impact on the aesthetics of the area. This impact would only be temporary and would be removed at the completion of the work. There may also be a temporary increase in turbidity during construction adjacent to the area of beach to receive fill and groin construction. Turbidity would return to normal levels once the construction activity ceases. Once completed the proposed project would result in an overall improved aesthetic quality. The placement of sand on the beach would restore the natural appearance of the shore. With the no-action alternative, the shoreline would continue to erode. This would result in the loss of existing shoreline, which would reduce the visual aesthetics of the area.

4.7 RECREATION

Virginia Key Beach Park, within the project area, is currently closed to the public due to the condition of the beach and park facilities. The beach would remain closed during project construction. Since the beach is currently closed there would be no adverse impact to beach related recreation during the period of construction. At some point after the project is constructed, the beach would be reopened to the general public for recreation. With the no-action alternative, the shoreline would continue to erode, reducing the amount of beach available for recreation. This would also result in the degradation or loss of shorefront property and park facilities thus further impacting beach recreational opportunities.

4.8 COASTAL BARRIER RESOURCES

The purpose of the Coastal Barrier Resources Act is to minimize the loss of human life, wasteful expenditure of Federal moneys; and the damage to fish, wildlife, and other resources associated with the coastal barriers along the Atlantic coast by restricting future Federal expenditures and financial assistance, which have the effect of encouraging development of these coastal barriers. There are no designated Coastal Barrier Resource Act Units located within or adjacent to the project area.

4.9 WATER QUALITY

The proposed action would cause temporary increases in turbidity adjacent to the beach during construction. The State of Florida water quality regulations require that water quality standards not be violated during dredging operations. The standards state that turbidity outside the mixing zone shall not exceed 29 NTU's above background. Results from turbidity monitoring at previous beach nourishment projects have shown that the turbidity did not exceed the standard. Various protective measures and monitoring programs would be conducted during construction to ensure compliance with state water quality criteria. Should turbidity exceed State water quality standards as determined by monitoring, the contractor would be required to cease work until conditions returned to normal. The proposed action has been evaluated in accordance with Section 404 of the Clean Water Act and a 404(b) evaluation report has been included as Appendix A to this EA.

4.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The preliminary assessment indicated that no hazardous, toxic, radioactive (HTRW), or other harmful substances are impacting the project area. There are no hazardous, toxic, or radioactive waste sites or producers in the project area that would be affected as a result of the preferred alternative. No impacts associated with the disturbance of such sites are anticipated from either the recommended or no-action alternatives.

During construction further HTRW awareness would be practiced. With the use of construction equipment in the in the areas around the borrow site, beach fill site, and groin construction there is the potential for hydrocarbon spills or other effluent releases. However, the likelihood of significant accidents and releases of this sort is very remote. The contract specifications will require the contractor to develop accident and spill prevention plans. The no-action alternative should not allow conditions to develop that would increase accidents or releases of this sort.

4.11 AIR QUALITY

Direct emissions from the proposed action would be confined to exhaust emissions of labor transport equipment, and construction equipment. These emissions would likely be well under the *de minimus* levels for ozone non-attainment areas as cited in 40 CFR 91.853; that is, projects implemented cannot produce total emissions greater or equal to 100 tons per year of Volatile Organic Compounds (VOCs). Any indirect increase in emissions (indirect emissions), as a result of the proposed action is beyond the control and maintenance of the USACE. Consequently, a conformity determination with the Florida State Implementation Plan is inappropriate for increases of indirect emissions from the proposed action. As with the proposed action and alternatives, the no-action alternative will see continued development, which may cause marginal adverse impacts to air quality. The extent of these impacts, however, is difficult to predict.

4.12 NOISE

With the implementation of the proposed action there would be a temporary increase in noise levels in the vicinity of the project area during construction. All construction equipment would be properly maintained to minimize the effects of noise. Increases from the current noise levels as a result of the proposed action would be localized and minor, and limited to the time of construction. There would be no noise-related impacts associated with the no-action alternative.

4.13 ENERGY REQUIREMENTS AND CONSERVATION

The energy requirements for this construction activity would be confined to fuel for labor transportation, trucks to haul sand, and other construction equipment. The expenditure of energy would be much less using the proposed on-site sand source than obtaining material from other sources described in the alternatives section. For example, the use of sand from offshore or other distant upland sources would require the use of more energy to transport the sand for beach fill. The no-action alternative would allow conditions to develop that may endanger coastal property from storm surges and wave erosion during future storm events. On-site preventive measures and post clean up under the no-action alternative would likely demand greater energy than that required of the proposed action.

4.14 NATURAL OR DEPLETABLE RESOURCES

In this case, the beach quality sand used to construct the project is the depletable resource. Using sand from the proposed on-site upland area will deplete the sand at that site. The gasoline and diesel fuel used by the dredge and other construction equipment and the material used to construct the groins are also depletable resources.

4.15 SOLID WASTE

The contract plans and specifications will require the contractor to place any solid waste (excluding clearing debris) in containers that would be emptied on a regular schedule.

All handling and disposal shall be conducted to prevent any contamination. The contractor will be required to transport all solid waste off the project site and dispose of it in compliance with Federal, State, and local requirements for solid waste disposal.

4.16 DRINKING WATER

The proposed action would not affect any drinking water resources.

4.17 CUMULATIVE IMPACTS

Cumulative impact is the impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions (40 CFR 1508.7). The placement fill material on the beach would cover those relatively non-motile benthic invertebrates. However, many of those species not able to escape the construction area are expected to recolonize after project completion. Some seagrasses will be lost due to construction. It is expected that over time, seagrass would recolonize the areas disturbed by construction activities. Mitigation for any impacts to nearshore seagrasses due to project construction would be performed as part of the proposed project. A specific mitigation plan would be developed in coordination with the Florida Department of Environmental Protection, Dade County Department of Environmental Resources Management, National Marine Fisheries Service and the U.S. Fish and Wildlife Service. The proposed action would result in long-term benefits, which should outweigh any short-term environmental losses. The cumulative impact of shore protection projects along the Florida coast has been to restore and maintain many beaches which otherwise would have experienced severe erosion or would have totally disappeared. In addition, these activities have reduced property damage and helped maintain property value.

4.18 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

4.18.1 IRREVERSIBLE

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. One example of an irreversible commitment might be the mining of a mineral resource. The use of sand from the proposed upland would (for all practical purposes) irreversibly deplete the suitable sand reserves. The energy and fuel used during construction would also be an irreversible commitment of resources.

4.18.2 IRRETRIEVABLE

An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resource as they presently exist are lost for a period of time. An example of an irretrievable loss might be where a type of vegetation is lost due to road construction. Benthic organisms within the beach fill area that would be eliminated during construction would be irretrievably lost for a period of time. However, the high rate of repopulation expected from these organisms reduces the significance of the loss. The loss of approximately 8290 ft^2 of seagrass would be an irretrievable loss. However, the loss of seagrass would be appropriately mitigated.

4.19 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS

Species of relatively non-motile infaunal invertebrates that inhabit the beach within the proposed project area will be unavoidably covered during beach fill operations. Those species that are not able to escape the construction area are expected to recolonize after project completion. There would be an unavoidable decrease in water clarity and increase turbidity and sedimentation in the immediate vicinity of the construction area. This impact will be temporary and should disappear shortly after construction activities cease. The loss of approximately 8,290 ft^2 of seagrass due to the placement of beach fill and groin construction is an unavoidable impact. Any seagrass loss would be mitigated.

4.20 LOCAL SHORT-TERM USES AND MAINTENANCE/ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Implementation of the proposed project will conserve for continued public use and enjoyment a rapidly eroding stretch of public beach. The project will create and maintain a broader beach in the area that is critically eroded and will maintain the existing beach within the remainder of the proposed project area. This will help enhance the recreational potential of the site. In addition, it will provide a degree of long-term protection of the public structures from storm-induced waves and tides. The project will have some adverse effects on the environment, including the loss of some marine benthic invertebrates and seagrass. The loss of seagrass will be appropriately mitigated.

4.21 UNCERTAIN, UNIQUE, OR UNKNOWN RISKS

There is some uncertainty concerning the extent and nature of impacts and resources to be impacted. There also are some operational risks due to the nature of the operation and difficulty working in an beach/ocean environment. A number of measures are taken to minimize risk (see Environmental Commitments below). The reasonably foreseeable range of impacts would indicate no major, significant, or catastrophic consequences.

4.22 ENVIRONMENTAL COMMITMENTS

The U.S. Army Corps of Engineers and contractors commit to avoiding, minimizing or mitigating for adverse effects during construction activities by including the following commitments in the contract specifications:

(1) Inform contractor personnel of the potential presence of sea turtles and manatees in the project area, their endangered status, the need for precautionary measures, and the Endangered Species Act prohibition on taking sea turtles, manatees and other threatened or endangered species.

(2) Take precautions during construction activities to insure the safety of the manatee. To insure the contractor and his personnel are aware of the potential presence of the manatee in the project area, their endangered status, and the need for precautionary measures, the contract specifications would include the standard protection clauses

concerning manatees. The contractor would instruct all personnel associated with the construction of the project about the presence of manatees in the area and the need to avoid collisions with manatees. All vessels associated with the project shall operate at 'no wake' speeds at all times while in shallow waters, or channels, where the draft of the boat provides less than three feet clearance of the bottom. Boats used to transport personnel shall be shallow draft vessels, preferably of the light-displacement category, where navigational safety permits. Vessels transporting personnel between the landing and any workboat shall follow routes of deep water to the extent possible. Shore crews or personnel assigned to the disposal site for the workshift shall use upland road access if available. All personnel would be advised that there are civil and criminal penalties for harming, harassing, or killing manatees, which are protected under the Endangered Species Act and the Marine Mammal Protection Act. The contractor shall be held responsible for any manatee harmed, harassed, or killed as a result of the construction of the project. The contractor shall keep a log of all sightings, collision, injuries, or killings of manatees during the contract period. Any manatee deaths or injuries will be immediately reported to the Corps of Engineers and the USFWS (Vero Beach Office).

(3) To minimize adverse impacts to sea turtles, the Corps will implement all the terms and conditions applicable to Dade County as outlined in the USFWS Biological Opinion for Region III of the Coast of Florida Erosion and Storm Effects Study issued on October 24, 1996. Measures to minimize adverse effects to sea turtles are summarized below:

a. Nourished beaches would be plowed to a depth of at least 36 inches within one week following the completion of the entire beach nourishment (or sooner on completed sections) if sand compaction is greater than 500 cone penetrometer units.

b. Nourished beaches would be checked for compaction every 500 feet along the beach fill area. One station shall be at the seaward edge of the dune/bulkhead line (when material is placed in this area); one station shall be located between the dune line and the high water line; and one station shall be located just landward of the mean high water line. At each station three readings would be made at 6, 12, and 18-inch depths three times (three replicates). If any two or more adjacent stations have compaction at the same depth greater than 500 cone penetrometer units, the area would be plowed to a depth of at least 36 inches immediately prior to April 1. This process would be completed for three consecutive years following project completion.

c. Nest relocation activities must begin 65 days prior to nourishment activities which occur within the nesting and hatching season (April 1 - November 30) or by April 1, whichever is later. Nest surveys and relocations shall continue through the end of the project or September 30, whichever is earlier.

d. Nest surveys and relocations would be conducted by personnel with prior experience and training in nest survey and relocation procedures, and with a valid permit from the Florida Fish and Wildlife Conservation Commission (FWC).

e. Nests would be relocated between sunrise and 9 a.m. each day, and the relocation would be to a nearby hatchery in a secure setting where artificial lighting would not conflict with hatchling orientation.

f. In the event a turtle nest is dug up by beach construction activities, the contractor shall immediately notify the FWC permitted individual responsible for nest relocation so that the nest can be moved to the beach hatchery.

g. A report describing the actions taken to implement the terms and conditions shall be submitted to the USFWS within 60 days of completion of the proposed work for each year when activity has occurred. The report shall include the dates of actual construction activities, names and qualifications of personnel involved in nest surveys and relocation activities, descriptions and locations of the hatcheries, nest survey and relocation results and hatching success of the nests.

h. Nourished beaches would be surveyed for escarpments immediately after construction and prior to April 1, for 3 subsequent years. Any escarpments that exceed 18 inches in height and 100 feet length would be leveled by April 1.

i. Measures will be taken to reduce nighttime beach lighting including: eliminating extraneous lighting to an amount necessary for safe operations and safety of personnel.

(4) Monitor turbidity at the beach nourishment site during construction. Should monitoring reveal turbidity levels above State standards, outside the allowable mixing zone, work would be suspended until turbidity levels return to within those standards.

(5) Precautions would be implemented during construction to minimize potential impacts to seagrass and any hardbottom communities adjacent to the construction area.

(6) A biological-monitoring program to assess possible impacts of construction operations seagrass and live-bottom habitats near the renourishment area would be conducted.

4.23 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

4.23.1 NATIONAL ENVIRONMENTAL POLICY ACT OF 1969

Environmental information on the project has been compiled and this Environmental Assessment has been prepared for public review and comment. The project is in compliance with the National Environmental Policy Act.

4.23.2 ENDANGERED SPECIES ACT OF 1973

In a letter dated February 8, 2001 the Corps submitted project information to the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act. In the letter the Corps had determined that the proposed project activities were covered under the Regional Biological Opinion (RBO) concerning hopper dredging on the South Atlantic Coast as amended on September 25, 1997. The Corps also requested informal consultation for Johnson's seagrass until it can be to be present or not in the vicinity of the project area. This consultation is still ongoing. In a letter dated February 12, 2001 the Corps submitted a Biological Assessment to the U S Fish and Wildlife Service (USFWS) pursuant to Section 7 of the Endangered Species Act. This consultation is still ongoing. Refer to Appendix C for correspondence. Pending the conclusion of the Section 7 consultations with NMFS and USFWS this project will be in full compliance with the Act.

4.23.3 FISH AND WILDLIFE COORDINATION ACT OF 1958

This project has been coordinated with the U.S. Fish and Wildlife Service (USFWS). A Draft Coordination Act Report (CAR) dated March 2001was submitted by the USFWS (refer to Appendix D). This project is in full compliance with the Act.

4.23.4 NATIONAL HISTORIC PRESERVATION ACT OF 1966 (INTER ALIA)

(PL 89-665, the Archeology and Historic Preservation Act (PL 93-291), and executive order 11593) Archival research, field investigations and consultation with the Florida State Historic Preservation Officer (SHPO), has been conducted in accordance with the National Historic Preservation Act, as amended; the Archeological and Historic Preservation Act, as amended and Executive Order 11593. A determination of no adverse effect was sent to the SHPO on January 10, 2001. In a letter dated January 17, 2002, the SHPO concurred with the determination. At this stage, the project is in compliance with each of these Federal laws.

4.23.5 CLEAN WATER ACT OF 1972

The project is in compliance with this Act. Application for a Section 401 water quality certification will be submitted to the Florida Department of Environmental Protection. All State water quality standards would be met. A Section 404(b) evaluation is included in this report as Appendix A.

4.23.6 CLEAN AIR ACT OF 1972

Refer to Section 4.11 in this EA, which discusses compliance with the Clean Air Act General Conformity Rules. No air quality permits would be required for this project. This project has been coordinated with the U.S. Environmental Protection Agency (EPA) and is in compliance with Section 309 of the Act. The Draft EA will be submitted to EPA for their review.

4.23.7 COASTAL ZONE MANAGEMENT ACT OF 1972

A federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as Appendix B. State consistency review will be performed during the coordination of the draft EA. The State has determined that, at this stage, the project is consistent with the Florida Coastal Zone Management Program.

4.23.8 FARMLAND PROTECTION POLICY ACT OF 1981

No prime or unique farmland would be impacted by implementation of this project. This act is not applicable.

4.23.9 WILD AND SCENIC RIVER ACT OF 1968

No designated Wild and Scenic river reaches would be affected by project related activities. This act is not applicable.

4.23.10 MARINE MAMMAL PROTECTION ACT OF 1972

Incorporation of the safe guards used to protect threatened or endangered species during construction operations would also protect any marine mammals in the area, therefore, this project is in compliance with the Act.

4.23.11 ESTUARY PROTECTION ACT OF 1968

No designated estuary would be affected by project activities. This act is not applicable.

4.23.12 FEDERAL WATER PROJECT RECREATION ACT

This Act does not apply.

4.23.13 FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

The project has been coordinated with the National Marine Fisheries Service (NMFS) and is in compliance with the act (refer to correspondence in Appendix C from NMFS).

4.23.14 SUBMERGED LANDS ACT OF 1953

The project would occur on submerged lands of the State of Florida. The project has been coordinated with the State and is in compliance with the act.

4.23.15 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

There are no designated coastal barrier resources in the project area that would be affected by this project. These acts are not applicable.

4.23.16 RIVERS AND HARBORS ACT OF 1899

The proposed work would not obstruct navigable waters of the United States. The project is in full compliance.

4.23.17 ANADROMOUS FISH CONSERVATION ACT

Anadromous fish species would not be affected. The project has been coordinated with the National Marine Fisheries Service and is in compliance with the act.

4.23.18 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

No migratory birds would be affected by project activities. The project is in compliance with these acts.

4.23.19 MARINE PROTECTION, RESEARCH AND SANCTUARIES ACT

The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal (i.e. groin construction). Therefore, the Marine Protection, Research and Sanctuaries Act does not apply to this project. The disposal activities addressed in this EA have been evaluated under Section 404 of the Clean Water Act.

4.23.20 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

This act requires preparation of an Essential Fish Habitat (EFH) Assessment and coordination with the National Marine Fisheries Service (NMFS). The EFH Assessment has been integrated within the Draft EA and will be coordinated with NMFS during the normal NEPA coordination.

4.23.21 E.O. 11990, PROTECTION OF WETLANDS

No wetlands, as define in the Executive Order, would be affected by project activities. This project is in compliance with the goals of this Executive Order.

4.23.22 E.O. 11988, FLOOD PLAIN MANAGEMENT

The proposed project is in the base flood plain (100-year flood) and has been evaluated in accordance with Executive Order 11988. Relocation of the project outside of the flood plain would not be responsive to the shoreline stabilization needs of the Virginia Key Shoreline Stabilization Project, and was not considered further. A non-flood plain alternative for the potential development that may be induced as a result of project implementation would be to restrict all future development to those areas outside of the flood plain or elevated above the flood plain. Potential flood plain development as a result of project implementation would not likely occur as Dade County has designated the property as a restoration site.

4.23.23 E.O. 12898, ENVIRONMENTAL JUSTICE

The proposed action would not result in adverse human health or environmental effects, nor would the activity impact subsistence consumption of fish and wildlife. The project is in compliance.

4.23.24 E.O. 13089, CORAL REEF PROTECTION

The proposed action would not affect U.S. coral reef ecosystems as define in the Executive Order. Project is in compliance.

4.23.25 E.O. 13112, INVASIVE SPECIES

The proposed action will not affect the status of any invasive species. Project is in compliance.

5 LIST OF PREPARERS

The following personnel involved in preparing this Environmental Assessment:

Preparer	Discipline	Role
Michael Dupes	Biology	Principal Writer
Thomas Birchett	Archeology	Historic Properties
Grady Caulk	Archeology	Historic Properties
Doug Rosen	Coastal Geology	Geotechnical Analysis
Jonas White	Civil Engineering	Plan Formulation
Thomas Martin	Coastal Engineering	Engineering Design
Peter Besrutschko	Environmental Engineering	HTRW Assessment

6 PUBLIC INVOLVEMENT

6.1 SCOPING AND DRAFT EA

Scoping for the proposed action was initiated during the reconnaissance phase by a letter dated July 24, 2000. A second scoping letter was issued on January 29, 2001 for the feasibility phase of the study. The scoping letters were distributed to the appropriate Federal, State and Local agencies, appropriate city and county officials, and other parties known to be interested in the project. Copies of the scoping letters, the list of addressees used to distribute the letters, and letters of response are included in Appendix C, Pertinent Correspondence. A Notice of Availability (NOA) of the draft EA will be prepared and sent to appropriate Federal, State and Local agencies, appropriate city and county officials and other interested parties.

6.2 AGENCY COORDINATION

The proposed project has been coordinated with the following agencies: U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida State Clearinghouse, Florida State Historic Preservation Officer (SHPO), Florida Fish and Wildlife Conservation Commission, and the Florida Department of Environmental Protection. Any agency coordination letters are in Appendix C.

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APPENDIX A

SECTION 404(B) EVALUATION

PRELIMINARY
SECTION 404(b) EVALUATION

SECTION 111 SHORE STABILIZATION PROJECT
VIRGINIA KEY, DADE COUNTY, FLORIDA

I. Project Description

a. Location. The project is located in on Virginia Key in Dade County on the southeast coast of Florida. Refer to location map, figure 1, in the Environmental Assessment (EA).

b. General Description. The proposed action consists of rehabilitating 24 existing timber-pile groins, constructing three new timber-pile groins and placing beach fill in the areas between the new groins. The borrow area proposed for the beach fill is located on Virginia Key immediately adjacent to the project area.

c. Authority and Purpose. A Section 905(b) preliminary assessment was conducted in response to a letter dated July 25, 2000 from U.S. House of Representatives' Carrie P. Meek. The 905(b) assessment indicated that further detailed study was warranted to determine if mitigative measures were appropriate at Virginia Key due to negative shoreline impacts from previous improvements of the Federal navigation project at Miami Harbor. The feasibility study is being conducted under the Corps' continuing authority provided by Section 111 of the River and Harbor Act of 1968, as amended. Section 111 reads as follows:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damage attributable to Federal navigation works. The cost of implementing measures under this authority would be shared by non-Federal interests in the same proportion as the costs for the project causing the damage. The cost of operating and maintaining such projects shall be borne entirely by the non-Federal interests. No such project shall be constructed without specific authorization by Congress if the estimated first cost exceeds $5,000,000."

d. General Description of Dredged or Fill Material.

(1) General Characteristics of Material. The material to be used as beach fill is generally light tan to tan, poorly graded quartz and carbonate sand with a trace of silt. The composite mean grain size of the borrow areas is 0.32mm with a average silt content of 7.5 percent.

(2) Quantity of Material. The amount of sand needed to fill 1,300 feet of beach is estimated at 8,050 cubic yards. Approximately 710 cubic yards of sand would be needed to construct the dune feature. To construct the timber-pile groins, approximately 182 20-ft tapered piles, 6,640 linear feet of 6" x 8" bracing, and 19,920 linear feet of 3" x 8"slats wood be used. All timber material will treated with chromated copper arsenate (CCA).

(3) Source of Material. The proposed source of fill material for the beach nourishment is located upland in two sand mounds adjacent to the project area. These sand mounds consist of material previously excavated from Key Biscayne and stockpiled on Virginia Key as a potential source of beach fill material. The material required to construct the timber groins will come from a commercial supplier.

e. Description of the Proposed Construction Site.

(1) Location. The proposed construction site is located along the shoreline of Virginia Key adjacent to Bear Cut. The length of the project area is approximately 3,400 feet and lies within the boundaries of an area known, as the Old County Park owned by the City of Miami. Refer to figure 2 in EA.

(2) Size. The proposed beach fill is approximately 1,300 feet long with a variable berm width between the groins. The proposed dune feature is approximately 910 long, two feet high and 22 feet wide. Twenty-eight timber groins will be constructed ranging in length from 30 to 120 feet.

(3) Type of Site. The site for disposal of the sand material and groin construction is a segment of eroded, sandy, recreational beach and inshore seabed.

(4) Type of Habitat. The area proposed for beach fill and groin construction consists of a currently eroding carbonate and quartz sand beach and inshore seabed. Extensive seagrass beds exist within a few feet of the shoreline.

(5) Timing and Duration of Dredging. No dredging will occur. The source of the material to be used for beach fill is located upland adjacent to the project site; therefore, no dredging would be performed. The exact timing of construction is not known but is anticipated that it will occur during late 2002 and early 2003.

f. Description of Disposal Method. The material will be excavated from the borrow area and then be transferred and dry placed on the beach by mechanical means such as front-end loaders, dump trucks, and/or bulldozers. The beach will be graded to achieve the desired construction profile.

II. Factual Determinations

a. Physical Substrate Determinations.

(1) Substrate Elevation and Slope. The beach fill will be constructed with a berm elevation of +6.0 feet mean low water with a variable berm width conforming to the anticipated equilibrium shape of the beach between the newly constructed groins. The front slope of the beach fill will be 1 vertical on 10 horizontal. The timber groins will be constructed perpendicular to the shore. The top of the groins will be at elevation +4 mlw. The dune feature is designed into five 150-foot segments with 20-foot gaps separating each segment. The crest width will be 2 feet with side slopes of 1 vertical on 5 horizontal.

(2) Type of Fill Material. The material to be used as beach fill is generally light tan to tan, poorly graded quartz and carbonate sand with a trace of silt. The composite mean grain size of the borrow areas is 0.32mm with a average silt content of 7.5 percent.

(3) Dredge/Fill Material Movement. The fill material will be subject to erosion by waves with the net movement of fill material to the south. The groins will be permanent structures

(4) Physical Effects on Benthos. The beach fill may cover some benthic organisms that are not mobile. Recolonization soon after project completion is expected to replace those organisms that do not survive project construction. It is anticipated that no long-term adverse impacts will occur.

b. Water Circulation, Fluctuation and Salinity Determination.

(1) Water Column Effects. During beach fill operations and groin construction, turbidity would increase temporarily in the water column. The increased turbidity would be short-term; therefore the proposed construction would have no long-term or significant impacts, if any, on salinity, water chemistry, clarity, color, odor, taste, dissolved gas levels, nutrients or eutrophication.

(2) Current Patterns and Circulation. The current flow through Bear Cut, which is adjacent to the project area, is driven primarily by the astronomical tides. The current velocities and direction therefore fluctuate, with two flood (incoming) and two ebb (outgoing) tides during a 24-hour period. The project will have no significant effect on existing current patterns, current flow, velocity, stratification, or the hydrologic regime in the area.

(3) Normal Water Level Fluctuations and Salinity Gradients. The tide in the project area is "semi-diurnal" with a mean tide range and spring tide range of 2.05 and 2.46 feet, respectively. Salinity is that of oceanic water. Placing beach fill and constructing groins would not affect normal tide fluctuations or salinity.

c. Suspended Particulate/Turbidity Determinations.

(1) Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal Site. There may be a temporary increase in turbidity levels in the project area during groin construction and the placement of beach fill. Turbidity will be short-term and localized and no significant adverse impacts are expected. State water quality standards for turbidity outside an allowable mixing zone will not be exceeded.

(2) Effects on the Chemical and Physical Properties of the Water Column. There would be little, if any adverse effects to chemical and physical properties of the water as a result of using the proposed fill material.

(a) Light Penetration. Some decrease in light penetration may occur in the immediate vicinity of the beach fill area. This effect will be temporary, limited to the immediate area of construction, and will have no adverse impact on the environment.

(b) Dissolved Oxygen. Dissolved oxygen levels will not be altered by this project due to the high energy wave environment and associated adequate reaeriation rates.

(c) Toxic Metals, Organics, and Pathogens. No toxic metals, organics, or pathogens are expected to be released by the project.

(d) Aesthetics. The aesthetic quality of the water in the immediate area of the project will be reduced during construction due to increased turbidity. This will be a short-term and localized condition. The placement of clean beach compatible sand on an erosive beach will likely improve the aesthetic quality of the immediate area.

(3) Effects on Biota.

(a) Primary Productivity and Photosynthesis. Approximately 8,290 ft^2 (771 m^2) of seagrass will be covered by beach fill material or disturbed by groin construction. These impacts would be minimal and would be appropriately mitigated and therefore, is not considered to have a significant affect on primary productivity and photosynthesis.

(b) Suspension/Filter Feeders. An increase in turbidity could adversely impact burrowing invertebrate filter feeders within and adjacent to the immediate construction area. It is not expected that a short-term, temporary increase in turbidity will have any long-term negative impact on these highly fecund organisms.

(c) Sight Feeders. No significant impacts on these organisms are expected as the majority of sight feeders are highly motile and can move outside the project area.

d. Contaminant Determinations. Material from the proposed borrow site will not introduce, relocate, or increase contaminants at the fill area. The material is clean sand and would be compatible with the existing beach.

e. Aquatic Ecosystem and Organism Determinations. The material from the proposed borrow area to be used as beach fill is similar enough to the existing beach substrate that no impacts are expected. The materials meet the exclusion criteria, therefore, no additional chemical-biological interactive testing will be required.

(1) Effects on Plankton. No adverse impacts on autotrophic or heterotrophic organisms are anticipated.

(2) Effects on Benthos. The beach fill will bury some benthic organisms. Benthic organisms found in the intertidal areas along the project beach are adapted for existence in an area with considerable substrate movement, thus some will be able to burrow up through the fill material. Recolonization is expected to occur within a year after the construction activity ceases. No adverse long-term impacts to non-motile or motile benthic invertebrates are anticipated. Refer to Section 4.0 Environmental Effects, in the EA.

(3) Effects on Nekton. No adverse impacts to nektonic species are anticipated.

(4) Effects on the Aquatic Food Web. No adverse long-term impact to any trophic group in the food web is anticipated.

(5) Effects on Special Aquatic Sites.

(a) Hardground and Coral Reef Communities. There are no hardground or coral reef communities located in the immediate nearshore area that would be impacted by construction activities.

(6) Endangered and Threatened Species. There will be no significant adverse impacts on any threatened or endangered species or on critical habitat of any threatened or endangered species. Refer to Section 5.0 in the EA for measures that will be implemented to protect endangered and threatened species.

(7) Other Wildlife. No adverse impacts to small foraging mammals, reptiles, or wading birds, or wildlife in general are expected.

(8) Actions to Minimize Impacts. All practical safeguards will be taken during construction to preserve and enhance environmental, aesthetic, recreational, and economic values in the project area. Specific precautions are discussed elsewhere in this 404(b) evaluation and in the EA for this project (refer to Sections 4.0 and 5.0 in the EA).

f. Proposed Disposal Site Determinations.

(1) Mixing Zone Determination. Clean sand, compatible with the existing beach, would be placed on the beach. This would not cause unacceptable changes in the mixing zone water quality requirements as specified by the State of Florida's Water Quality Certification permit procedures. No adverse impacts related to depth, current velocity, direction and variability, degree of turbulence, stratification, or ambient concentrations of constituents are expected from implementation of the project.

(2) Determination of Compliance with Applicable Water Quality Standards. Because of the inert nature of the material to be dredged, Class III water quality standards will not be violated.

(3) Potential Effects on Human Use Characteristics.

(a) Municipal and Private Water Supplies. No municipal or private water supplies will be impacted by the implementation of the project.

(b) Recreational and Commercial Fisheries. Fishing in the immediate construction area will be prohibited during construction. Otherwise, recreational and commercial fisheries will not be impacted by the implementation of the project.

(c) Water Related Recreation. Beach/water related recreation in the immediate vicinity of construction will be prohibited during construction activities. This will be a short-term impact.

(d) Aesthetics. The existing environmental setting will not be adversely impacted. Construction activities will cause a temporary increase in noise and air pollution caused by equipment as well as some temporary increase in turbidity. These impacts are not expected to adversely affect the aesthetic resources over the long term and once construction ends, conditions will return to pre-project levels.

(e) Parks, National and Historic Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves. No such designated sites are located within the project area. However, the Biscayne National Park is located south of the proposed project area and Biscayne Bay, which is designated as an Outstanding Florida Water is located immediately west. There is also a manatee no-entry zone and a critical wildlife area located immediately adjacent to the western shoreline of Virginia Key. It is not expected that construction activities will affect any resources in these areas.

g. Determination of Cumulative Effects on the Aquatic Ecosystem. There will be no cumulative impacts that result in a major impairment of water quality of the existing aquatic ecosystem as a result of the placement of fill at the project site.

h. Determination of Secondary Effects on the Aquatic Ecosystem. There will be no secondary impacts on the aquatic ecosystem as a result of the beach fill and groin construction.

III. Findings of Compliance or Non-compliance with the Restrictions on Discharge.

a. No significant adaptations of the guidelines were made relative to this evaluation.

b. No practicable alternative exists, which meets the study objectives, that does not involve discharge of fill into waters of the United States. Further, no less environmentally damaging practical alternatives to the proposed actions exist. Using material from an upland sand source adjacent to the project area avoids the impacts associated with dredging from and offshore borrow area and hydraulically placing the material on the beach. In addition, the impacts of using other sources on cultural resources, protected species, and other environmental factors would likely be equal to or greater than the impacts of the proposed action. The no action alternative would allow the present condition of the shoreline to continue and would not provide the benefits needed for storm damage protection.

c. After consideration of disposal site dilution and dispersion, the discharge of fill materials will not cause or contribute to, violations of any applicable State water quality standards for Class III waters. The discharge operation will not violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

d. The disposal of fill material for beach nourishment will not jeopardize the continued existence of any species listed as threatened or endangered or result in the likelihood of destruction or adverse modification of any critical habitat as specified by the Endangered Species Act of 1973, as amended. Standard conditions for monitoring and relocating turtle nests would be employed.

e. The placement of fill material will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreational and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. The life stages of aquatic species and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values will not occur.

f. Appropriate steps have been taken to minimize the adverse environmental impact of the proposed action. The beach fill material contains low silt content, therefore, turbidity due to silt will be low when placed on the beach. Turbidity will be monitored so that if levels exceed State water quality standards of 29 NTU's above background, the contractor will be required to cease work until conditions return to normal.

g. On the basis of the guidelines, the proposed disposal site is specified as complying with the requirements of these guidelines.

APPENDIX B

COASTAL ZONE MANAGEMENT CONSISTENCY

FLORIDA COASTAL ZONE MANAGEMENT PROGRAM
FEDERAL CONSISTENCY EVALUATION PROCEDURES

SECTION 111 SHORE STABILIZATION PROJECT
VIRGINIA KEY, DADE COUNTY, FLORIDA

1. Chapter 161, Beach and Shore Preservation. The intent of the coastal construction permit program established by this chapter is to regulate construction projects located seaward of the line of mean high water and which might have an effect on natural shoreline processes.

Response: The proposed plans and information will be submitted to the state in compliance with this chapter.

2. Chapters 163(part II), 186, and 187, County, Municipal, State and Regional Planning. These chapters establish the Local Comprehensive Plans, the Strategic Regional Policy Plans, and the State Comprehensive Plan (SCP). The SCP sets goals that articulate a strategic vision of the State's future. It's purpose is to define in a broad sense, goals, and policies that provide decision-makers directions for the future and provide long-range guidance for an orderly social, economic and physical growth.

Response: The proposed project has been coordinated with various Federal, State and local agencies during the planning process. The project meets the primary goal of the State Comprehensive Plan through preservation and protection of the shorefront development and infrastructure.

3. Chapter 252, Disaster Preparation, Response and Mitigation. This chapter creates a state emergency management agency, with the authority to provide for the common defense; to protect the public peace, health and safety; and to preserve the lives and property of the people of Florida.

Response: The proposed project involves the placing of beach compatible material and constructing groins on an eroding beach to protect recreational development and infrastructure located at Virginia Key Beach Park in Dade County, Florida. Therefore, this project would be consistent with the efforts of Division of Emergency Management.

4. Chapter 253, State Lands. This chapter governs the management of submerged state lands and resources within state lands. This includes archeological and historical resources; water resources; fish and wildlife resources; beaches and dunes; submerged grass beds and other benthic communities; swamps, marshes and other wetlands; mineral resources; unique natural features; submerged lands; spoil islands; and artificial reefs.

Response: The proposed activity would stabilize an eroding recreational beach and potential sea turtle nesting habitat. The placement of beach fill and the construction of groins will unavoidably impact approximately 8290 ft^2 ($771 m^2$) or 0.19 acres of seagrass. The proposed project has been designed to impact the least amount of seagrass practicable. It is anticipated that, over time, the seagrass would recolonize the areas disturbed once construction is completed. Mitigation for impacts to nearshore seagrasses due to project construction would be performed as part of the proposed project. A specific mitigation plan would be developed in coordination with the Florida Department of Environmental Protection, Dade County Department of Environmental Resources Management, National Marine Fisheries Service and the U.S. Fish and Wildlife Service. The proposed project would comply with the intent of this chapter.

5. Chapters 253, 259, 260, and 375, Land Acquisition. This chapter authorizes the state to acquire land to protect environmentally sensitive areas.

Response: Since the affected property already is in public ownership, this chapter does not apply.

6. Chapter 258, State Parks and Aquatic Preserves. This chapter authorizes the state to manage state parks and preserves. Consistency with this statute would include consideration of projects that would directly or indirectly adversely impact park property, natural resources, park programs, management or operations.

Response: The proposed project area does not contain any state parks or aquatic preserves. However, Biscayne Bay, which is designated as an Outstanding Florida Water is located immediately west. There is also a manatee no-entry zone and a critical wildlife area located immediately adjacent to the western shoreline of Virginia Key. It is not expected that construction activities will affect any resources in these areas. The project is consistent with this chapter.

7. Chapter 267, Historic Preservation. This chapter establishes the procedures for implementing the Florida Historic Resources Act responsibilities.

Response: Archival research, field investigations and consultation with the Florida State Historic Preservation Officer (SHPO), has been conducted in accordance with the National Historic Preservation Act, as amended; the Archeological and Historic Preservation Act, as amended and Executive Order 11593. A determination of no adverse effect was sent to the SHPO on January 10, 2001. The project will be consistent with the goals of this chapter.

8. Chapter 288, Economic Development and Tourism. This chapter directs the state to provide guidance and promotion of beneficial development through encouraging economic diversification and promoting tourism.

Response: The proposed shoreline stabilization would provide more space for recreation and the protection of recreational facilities along the beach at Virginia Key Beach Park. This would be compatible with tourism for this area and therefore, is consistent with the goals of this chapter.

9. Chapters 334 and 339, Transportation. This chapter authorizes the planning and development of a safe balanced and efficient transportation system.

Response: No public transportation systems would be impacted by this project.

10. Chapter 370, Saltwater Living Resources. This chapter directs the state to preserve, manage and protect the marine, crustacean, shell and anadromous fishery resources in state waters; to protect and enhance the marine and estuarine environment; to regulate fishermen and vessels of the state engaged in the taking of such resources within or without state waters; to issue licenses for the taking and processing products of fisheries; to secure and maintain statistical records of the catch of each such species; and, to conduct scientific, economic, and other studies and research.

Response: The proposed beach fill may represent a temporary short-term impact to infaunal invertebrates by burying these organisms. However, these organisms are highly adapted to the periodic burial by sand in the intertidal zone. These organisms are highly fecund and are expected to return to pre-construction levels within 6 months to one year after construction. No significant adverse impacts to marine fishery resources are expected. Nourishment activities and groin construction could occur during the main part of the sea turtle nesting season. However, a nest relocation program would be implemented, therefore it is not expected that sea turtles would be significantly impacted by this project. Based on the overall impacts of the project, the project is consistent with the goals of this chapter.

11. Chapter 372, Living Land and Freshwater Resources. This chapter establishes the Game and Freshwater Fish Commission and directs it to manage freshwater aquatic life and wild animal life and their habitat to perpetuate a diversity of species with densities and distributions, which provide sustained ecological, recreational, scientific, educational, aesthetic, and economic benefits.

Response: The project will have no effect on freshwater aquatic life or wild animal life.

12. Chapter 373, Water Resources. This chapter provides the authority to regulate the withdrawal, diversion, storage, and consumption of water.

Response: This project does not involve water resources as described by this chapter.

13. Chapter 376, Pollutant Spill Prevention and Control. This chapter regulates the transfer, storage, and transportation of pollutants and the cleanup of pollutant discharges.

Response: The contract specifications will prohibit the contractor from dumping oil, fuel, or hazardous wastes in the work area and will require that the contractor adopt safe and sanitary measures for the disposal of solid wastes. A spill prevention plan will be required.

14. Chapter 377, Oil and Gas Exploration and Production. This chapter authorizes the regulation of all phases of exploration, drilling, and production of oil, gas, and other petroleum products.

Response: This project does not involve the exploration, drilling or production of gas, oil or petroleum product and therefore, this chapter does not apply.

15. Chapter 380, Environmental Land and Water Management. This chapter establishes criteria and procedures to assure that local land development decisions consider the regional impact nature of proposed large-scale development. This chapter also deals with the Area of Critical State Concern program and the Coastal Infrastructure Policy.

Response: The proposed shoreline stabilization project will not have any regional impact on resources in the area. Therefore, the project is consistent with the goals of this chapter.

16. Chapters 381 (selected subsections on on-site sewage treatment and disposal systems) and 388 (Mosquito/Arthropod Control). Chapter 388 provides for a comprehensive approach for abatement or suppression of mosquitoes and other pest arthropods within the state.

Response: The project will not further the propagation of mosquitoes or other pest arthropods.

17. Chapter 403, Environmental Control. This chapter authorizes the regulation of pollution of the air and waters of the state by the Florida Department of Environmental Regulation (now a part of the Florida Department of Environmental Protection).

Response: An Environmental Assessment addressing project impacts has been prepared and will be reviewed by the appropriate resource agencies including the Florida Department of Environmental Protection. Environmental protection measures will be implemented to ensure that no lasting adverse effects on water quality, air quality, or other environmental resources will occur. Water Quality Certification will be sought from the State prior to construction. The project complies with the intent of this chapter.

18. Chapter 582, Soil and Water Conservation. This chapter establishes policy for the conservation of the state soil and water through the Department of Agriculture. Land use policies will be evaluated in terms of their tendency to cause or contribute to soil erosion or to conserve, develop, and utilize soil and water resources both onsite or in adjoining properties affected by the project. Particular attention will be given to projects on or near agricultural lands.

Response: The proposed project is not located near or on agricultural lands; therefore, this chapter does not apply.

SECTION 111

SHORELINE STABILIZATION REPORT
AND
DRAFT ENVIRONMENTAL ASSESSMENT

VIRGINIA KEY
DADE COUNTY, FLORIDA

APPENDIX A

ENGINEERING AND DESIGN

U.S. Army Engineer District
Jacksonville, FL

February 2002

ENGINEERING APPENDIX
SECTION 111 SHORELINE STABILIZATION REPORT AND DRAFT ENVIRONMENTAL ASSESMENT
VIRGINIA KEY, DADE COUNTY, FLORIDA

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INTRODUCTION

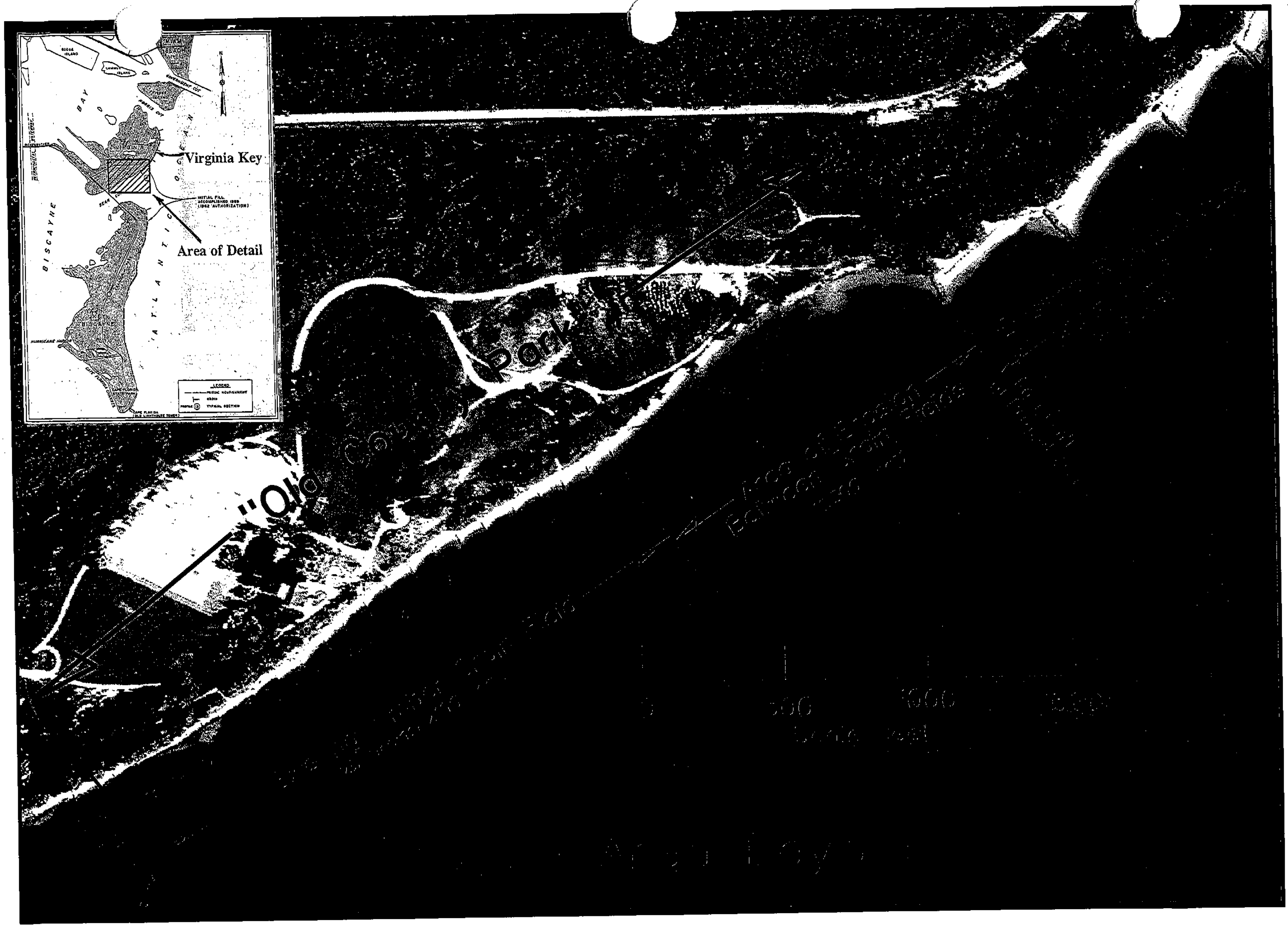
General.
The purpose of this Engineering Appendix is to provide detailed design information for restoration of the historic beach and groin field at Virginia Key, Dade County, Florida. Virginia Key is the middle island in a series of three barrier islands located south of the Miami Harbor Entrance Channel. A location map of the project area is provided in figure 1.

The project area is located along a 3,400-foot reach of the southeast shoreline of Virginia Key, as shown in figure 1. The study area extends along the entire length of shoreline of a public park formerly known as the "Old County Park". This park is owned by the city of Miami and is now closed to the public. The Old County Park shoreline is bounded on the west end by a marine sciences institute, and is bounded on the east end by another city-owned park, known as "North Park". A deauthorized Federal shore protection project consisting of a rubble mound groin field and beach renourishment project extends along North Park. Old County Park extends along the northern shoreline of Bear Cut, a tidal inlet connecting Biscayne Bay to the Atlantic Ocean.

Statement of Problem.
Two distinct subregions exist along the 3,400-foot Old County Park shoreline. The eastern 1,300 feet of the park's shoreline is an area of severe erosion, unprotected by any stabilizing structures. The western 2,100 feet of the park contains a relic timber groin field, and has been subjected to moderate to minimal erosion. Each of these areas are shown in figure 1.

The most severe erosion within the study area is along the 1,300-foot reach of unprotected shoreline at the eastern end of the park. This eroded area forms a shallow embayment which lies between the Federally-constructed rubble-mound groin field (to the east) and the park's timber-groin field (to the west). The erosion of this area has been mainly attributed to inadequate sediment bypassing past the rubble-mound groins to the east. A timber-pile groin field was constructed along the western 2,100 feet of the park's shoreline between 1948-56, and some groins were subsequently lengthened with concrete sections in 1965. Over the years this groin field deteriorated to its present-day condition, with most of the 25 existing timber groins showing varying degrees of damage, mainly from wood-boring marine organisms. As the timber groins deteriorated, some beach erosion began to occur along the western 2,100 feet of the park's shoreline.

The purpose of this Engineering Appendix is to investigate methods of stabilizing the shoreline within the limits of the Old County Park and restoring the historic groin field along the western portion of the park. This Appendix will present detailed information on project history, existing conditions, physical processes in the region, discussions of problems and alternative plans of improvement, cost estimates of selected alternatives, numerical modeling of proposed solutions, and detailed design of the selected alternative.


Virginia Key
Area of Detail
BISCAYNE
ATLANTIC
"Old
Park

PROJECT HISTORY

Virginia Key - Federal Beach Erosion Control Project.
The Federal Beach Erosion Control project on Virginia Key was authorized on 23 October 1962, and is described in HD 561-87-2. The project consisted of periodic beach renourishment along 1.8 miles of shoreline along the eastern and southeastern sides of the island, including the study area along the County Park. This initial beach fill placement along the east and southeast shorelines was completed in July 1969 when 176,800 cy of material were placed along the 1.8 mile length of the project between DNR survey monuments R-79 through R-86. This beach fill extended along the length of the present-day rubble-mound groin field, and along the eastern half of the Old County Park.

In 1974, construction of the rubble-mound groins was begun in response to the rapid erosion of the 1969 Virginia Key beach fill. This groin field consists of 13 rubble-mound structures constructed of locally-mined limerock, extending along approximately 1 mile of shoreline along the east and southeast shoreline of Virginia Key, from survey monument R-79 south to R-84. Each of these structures (except the northernmost groin) were designed to be porous in order to allow a degree of sediment bypassing. These groins have an average length of about 150 feet, and are spaced roughly 425 feet apart. A typical cross-section of these groins is shown in figure 2. The porosity of these structures was achieved by placing armor stone directly on the bedding stone layer, without a core or intermediate stone layer. The bedding layer is 2 feet thick, with a top elevation of –1.0 foot, mlw. The median armor stone size is 2000 lbs. The crest width of the armor stone layer is 6 feet at an elevation of +6.5 feet, mlw, and side slopes are 1v: 2h. This Federal project was deauthorized in 1990.

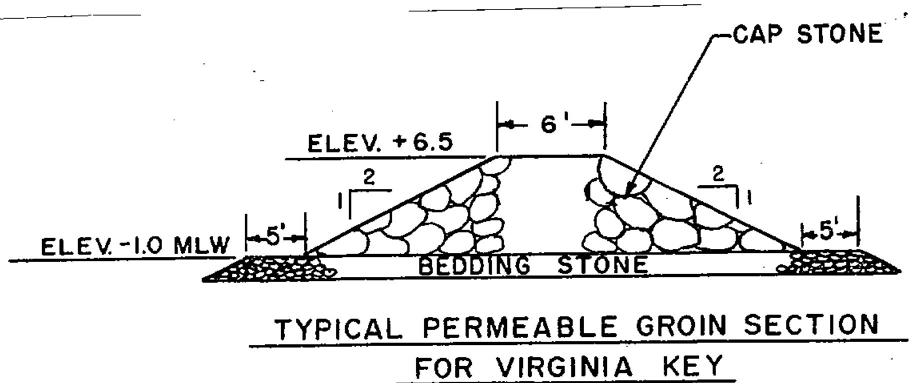


Figure 2. Cross-Section of Rubble-Mound Groin on Virginia Key

The first renourishment of the project was completed in April 1974, when 110,000 cy of material from the deepening of Miami Harbor were placed along the Virginia Key shoreline between monuments R-79 and R-84, in order to fill in the length of the recently-completed rubble-mound groin field.

Timber Groin Field.

Construction of the timber-pile groin field was begun in 1948. The design of these groins is presented in figure 3. In 1956 additional groins were added, bringing the total number of structures within the study area to 25. The groins range from 30 to 80 feet in length, and most are spaced about 100 feet apart. For the purposes of this study these timber groins will be numbered consecutively from east to west. In 1965, ten groins near the center of the groin field (groins #7 through #16) were extended further seaward using concrete king piles.

These 25 groins were initially constructed entirely of creosote-coated timber. Each groin was built using a series of the typical 10-foot sections which are shown in figure 3. As shown in the figure, 20-foot tapered piles were driven at 10-foot intervals along the length of each groin. Horizontal 6"x8" timbers connected the piles along the top (at elevation +4.0 ft, mlw) and 4 feet below the top (at elevation 0.0 ft, mlw). Ten-foot vertical 3"x8" timber piles were then driven into place along the cross-braces and nailed into place. A second identical set of cross-braces was then bolted into place along the opposite side of the groin. Galvanized connectors were used throughout the construction.

The 1965 modification to this groin field consisted of the seaward lengthening of ten groins near the center of the park. Concrete king piles, roughly 1.5 feet on each side, were driven at 12-foot intervals seaward of groins #7 through #16. These piles featured vertical grooves to allow the placement of horizontal slats between the piles to regulate the bypassing of sand. Four groins (#'s 6,9,11,12) were extended by one 12-foot section, while six groins (#'s 7,13,14,15,16,17) were extended by two 12-foot sections. Figures 4a and 4b show views of the shoreline and timber groin field at the Old County Park before the king-pile extensions were constructed, circa 1960.

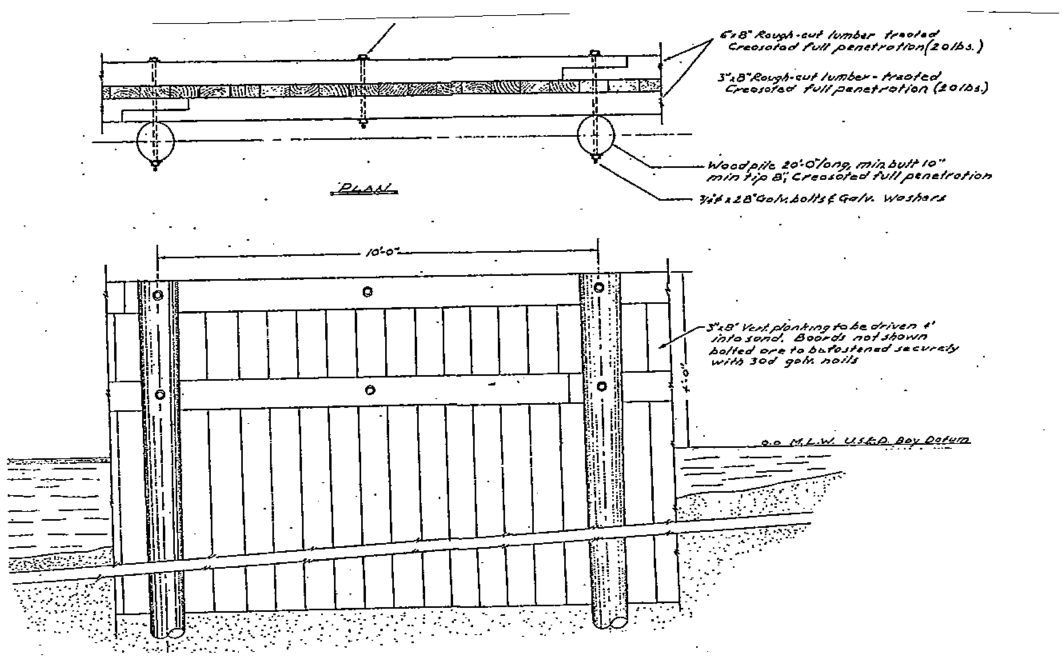


Figure 3. Cross-Section, Plan View of Timber-Pile Groins on Virginia Key

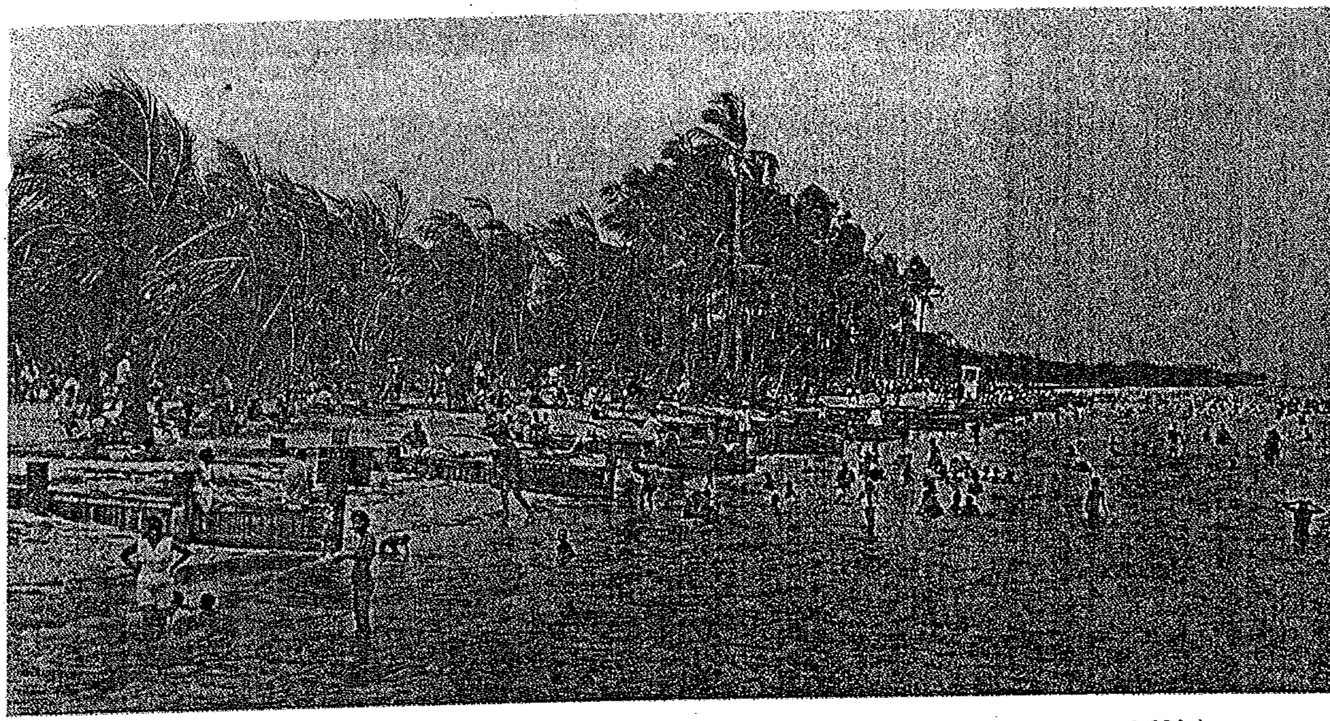


Figure 4a. Photograph of 'Old County Park' shoreline, Virginia Key. (circa 1960's)

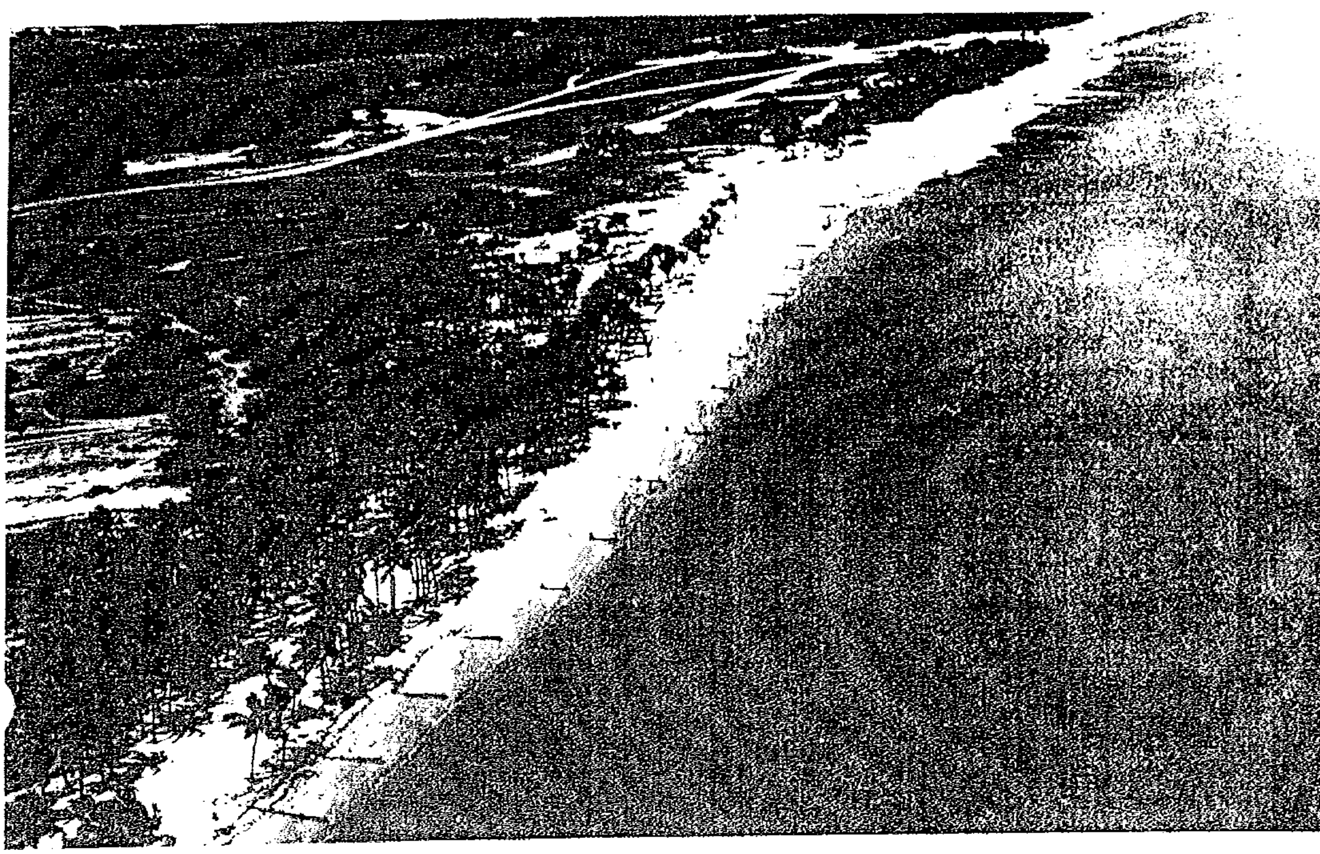


Figure 4b. Aerial photo of 'Old County Park' shoreline, Virginia Key, looking northeast. (circa 1960's)

EXISTING CONDITIONS

The shoreline along the east side of Virginia Key (North Park) is stabilized by the Federally-constructed rubble-mound groin field and beach renourishment project. This groin field holds most of the sediment placed along this reach of shoreline. Very little material is bypassed westward around this series of structures and as a result beach erosion occurs on the downdrift (west) side of the groin field, along the Old County Park shoreline.

Moderate to severe erosion has occurred along much of the 3,400-foot length of the Old County Park shoreline. Berm widths along the 2,100-foot reach of shoreline within the timber-pile groin field range from about 20 to 40 feet at high tide, but the most severe area of erosion is located at the east end of the park, immediately downdrift (west) of the westernmost Federally-constructed rubble-mound groin. This eroded area extends along a 1,300-foot gap between the existing Federally-constructed rubble-mound groin field and the relic timber-pile groin field, as shown in figure 1. No stabilizing structures exist along this reach, other than two loose piles of rock which are apparently the relics of destroyed rubble-mound groins. Berm widths along this reach of eroded shoreline average about 5 to 10 feet at high tide, and only the presence of stiff clay outcroppings along the beach and sea grass beds offshore serve to provide some degree of stability along this 1,300-foot gap between the two groin fields. This reach of shoreline has receded to the point where large trees have been undermined and are currently scattered along the shoreline and nearshore area. Figure 5a shows conditions along the 1,300-foot gap between groin fields. This photograph was taken in December 2000, near the time of low tide.

The existing timber groin field along the western portion of the park has deteriorated to the point that it is no longer an effective means of stabilizing the shoreline. Each of the 25 timber groins along the study area has deteriorated to some degree. During field inspections in December 2000 and January 2002, it was noted that severe deterioration had occurred to the portion of each groin which extended seaward of the mean low water line. Moderate to severe deterioration had occurred along the portion of each groin which spanned the intertidal zone (between mean high and mean low water). Most of the length of each structure landward of the mean high water line was buried, so an accurate determination of the condition of the upland portion of each groin was not possible without excavating each structure. Figure 5b shows a photograph of a typical timber groin taken in December 2000, near the time of low tide.

Under the present conditions, further erosion of the park's shoreline and further deterioration of the timber groins can be expected. There is evidence that very little material bypasses the rubble-mound groin field to the east of the Old County Park, and waves and tidal currents continually transport sediment westward out of the park area with very little natural replenishment. The timber groin field has deteriorated to such an extent that it is completely ineffective at low tide levels, and only marginally effective at higher tide levels.

Figure 5a. Photograph of conditions along 1,300-foot gap between groin fields, Virginia Key.

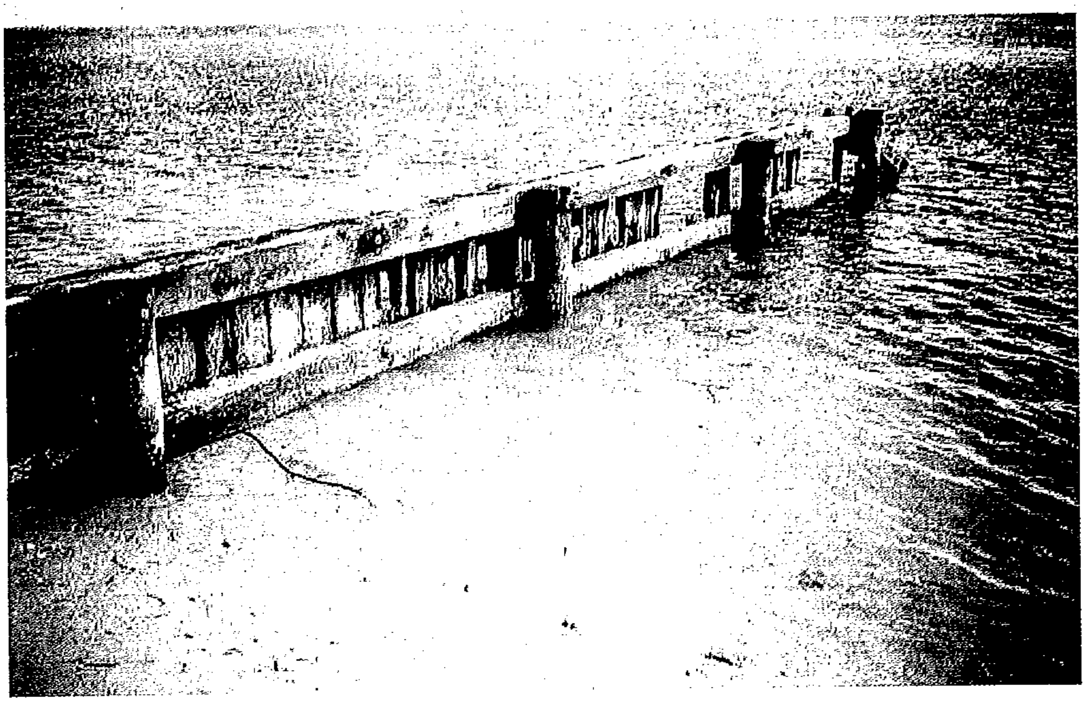


Figure 5b. Photograph of typical timber groin, Virginia Key.

PHYSICAL PROCESSES

General.

The physical data presented in this section consists of water level, wind, and wave measurements and hindcasts, and a discussion of recent storms which have affected the Virginia Key project area. Tidal datums in this report are provided by NOAA, and predicted storm surge elevations are provided by FEMA. The wind and wave data used in the engineering analysis and project design are based largely on Wave Information Study (WIS) hindcast data produced by the U. S. Army Corps of Engineers' Engineering Research and Development Center (ERDC, formerly the Waterways Experiment Station). Much of the data presented in this section was gathered over a considerable length of time; for example the WIS wave record extends across a 40-year period, from 1956 through 1995. Wind and water level data have also been documented over similarly long timeframes.

Water Levels.

General. Changes in water levels along the Virginia Key shoreline occur primarily as a result of three separate processes : astronomical tides, storm surges, and long-term sea level rise. Astronomical tides affect the area on a daily basis, while the effects of significant storm surges are much less frequent. The effects of sea-level rise during the 50-year economic life of the project are much more gradual and smaller in magnitude than the effects of tides or storm surges.

The effects of water levels on this project are important because in addition to the obvious flooding impacts associated with high water levels, larger ocean waves will be able to reach the project area when greater water depths exist offshore of the project area, and tidal current velocities through inlets (and the resulting scouring and/or shoaling) are greater when the tidal range is at its highest. The most severe conditions a shoreline will usually be subjected to will be a combination of astronomical high tide coupled with storm surge, while being subjected to storm wave attack. These conditions occur simultaneously on a fairly frequent basis (in varying degrees of severity) during the passage of tropical storms and winter 'northeasters'.

Although the most noticeable effects on water levels in the project area are due to astronomical tides and storm surges, the effects of long-term sea level rise cannot be ignored, due to its implications on the long-term management of the project. All three processes which affect ocean water levels will be discussed in the following sections.

Astronomical Tides. Astronomical tides are created by the gravitational pull of the moon and sun, and these tides are entirely predictable in magnitude and timing. The National Oceanic and Atmospheric Administration (NOAA) regularly publishes tide tables for selected locations along the coastlines of the United States and selected locations around the world. These tables provide times of high and low tides, as well as predicted tidal amplitudes.

Tides in the Dade County area are semidiurnal : two high tides and two low tides during each 24-hour period. Two measures of tidal range are commonly used : the mean tide range is defined as the difference between mean high water and mean low water, and represents an average range during the entire monthly lunar cycle. The range of tidal elevations between successive high and low tides is typically greater at any location during periods of a new or full moon. The spring tide range is the average semidiurnal range which occurs semimonthly when the moon is new or full. Both tide ranges in the area are relatively low - the mean tide range in Bear Cut is 2.05 feet and the spring tide range is 2.46 feet.

An historical database of astronomical tide data has been compiled by the National Oceanic and Atmospheric Administration (NOAA) at a tide station located on the concrete fishing pier at the Rosenstiel School of Marine and Atmospheric Science (University of Miami), located about 1/4 mile from the project area. Table 1 presents the benchmarks computed from this station, referenced to mean low water (mlw). All historical surveys, project design dimensions, prior reports and studies, and construction plans and specifications have been referenced to mlw since the project was authorized and constructed. Although mllw is currently used as the datum for most new projects, the mlw datum will be used in this report to maintain consistency with the historical database.

TABLE 1
NOAA Tidal Datums – Bear Cut (Virginia Key)

Tidal Datum	Elevation, ft above MLW
Highest Observed Water Level (15 Nov 94)	4.24 ft.
Mean Higher high Water (MHHW)	2.13
Mean High Water (MHW)	2.05
Mean Tide Level (MTL)	1.03
Mean Low Water (MLW)	0.00
Mean Lower Low Water (MLLW)	-0.14
Lowest Observed Water Level (29 Mar 94)	-1.19

Storm Surges. Storm surge is defined as the rise of the ocean surface above the normal astronomical tide level due to storm effects. Strong onshore winds pile up water near the shoreline, resulting in superelevated water levels along the coastal region and inland waterways. In addition, the lower atmospheric pressure which accompanies storms also contributes to a rise in water surface elevation. Extremely high wind velocities coupled with low barometric pressures (such as those experienced in tropical storms, hurricanes, and very strong northeasters) can produce very high, damaging water levels. For example, a peak surge of up to 10.6 feet mlw was measured along the Key Biscayne shoreline during the passage of Hurricane Andrew in 1992. Factoring out the 2.5-foot astronomical high tide resulted in a storm surge of 8.1 feet.

Storm surge levels versus frequency of occurrence were calculated for coastal counties throughout Florida by the Federal Emergency Management Agency (FEMA) as part of that agency's Flood Insurance Study [reference (e)]. The storm surge frequency curves for Dade County are shown in figure 6 below.

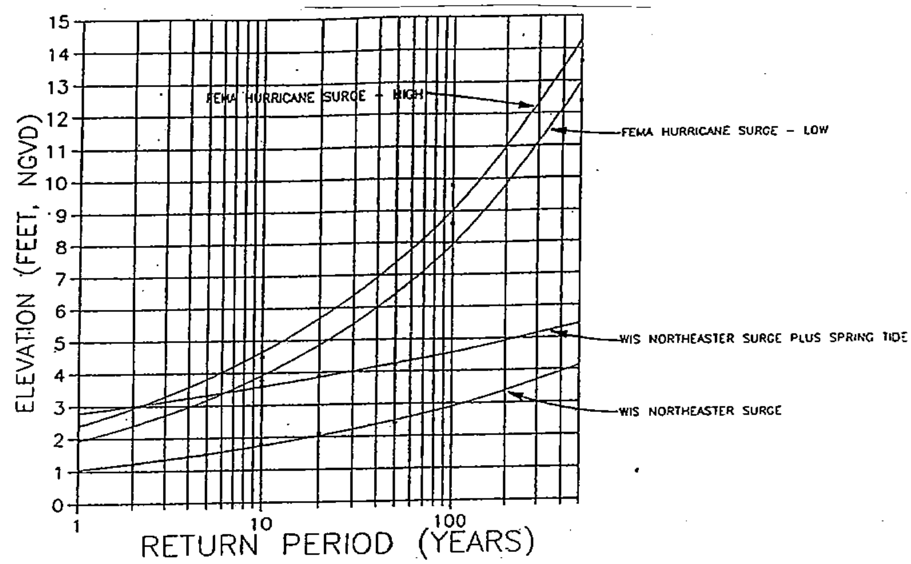


Figure 6. FEMA Storm Surge Frequency Curve.

Methodology developed by the National Academy of Sciences was used in the development of these series of storm surge curves. These curves include the effects of storm waves, and also include the wave dissipation effects of features such as dunes and vegetation, and coastal structures such as seawalls and buildings. Two sets of curves are provided on the graph in figure 6, consisting of a pair of hurricane-produced surge levels, and a pair of northeaster-produced surge levels.

The FEMA hurricane surge curves are interpolated from data points for the 10, 50, 100, and 500-year recurrence hurricane events. The 'high' curve was computed for hurricane surges along the southern portion of Dade County, while the 'low' curve was calculated for surges along the northern portion of the county. The differences between these two curves are mainly due to differences in wave runup levels at the northern and southern ends of the county.

Storm surge levels due to northeasters were generated from WIS data hindcasts. The 'northeaster' curves shown on this graph were interpolated from data points for the 2, 5, 10, 20, and 50-year recurrence events at Miami Beach. The WIS northeaster data does not include astronomical tide, so two 'northeaster' surge curves are provided in figure 6 : the lower curve shows surge only, while the upper curve shows the spring high tide superimposed on the lower curve. Since most northeasters last several days, the upper northeaster curve represents a realistic 'worse-case' scenario. The FEMA hurricane surge curves are extrapolated below the 10-year event, and the WIS northeaster curves are extrapolated above the 50-year event, so care should be used when determining surge levels based on these extrapolated portions of the storm surge curves.

Sea Level Rise. Eustatic sea level change is defined as a global change in the water surface elevations of the world's oceans. The total relative sea level change is the difference between the eustatic sea level and changes in local land surface elevations, and may include the rise or fall of the land as well as changes of the eustatic sea level. The eustatic sea level has varied widely over geologic time, and evidence suggests that sea levels in the past have been much higher, and much lower, than present-day levels.

Currently there is considerable debate about whether sea levels may be dropping due to the onset of a new ice age, or whether sea levels are rising due to polar ice cap melting associated with global warming. Research on this subject has been divided as to whether the long-term outlook favors a eustatic sea level rise or fall. Four widely-circulated studies have been performed since the Environmental Protection Agency first addressed the issue of sea-level rise in 1983. Figure 7 shows a graphic representation of the results of each study, including the year in which it was published, the predicted amount of sea level rise or fall by the year 2100, and the degree of uncertainty. As seen in this figure, the original 1983 study indicated the greatest sea level rise, at 2.0 meters by the year 2100. Subsequent studies by the National Research Council (NRC) have resulted in lower predictions, with smaller ranges of uncertainty. The latest NRC study was performed in 1990, and predicts a sea level rise of 0.5 meters by 2100, with a wider range of uncertainty : plus or minus 1 meter.

The 1987 report published by the NRC recommended that sea level rise should be considered during the initial design of coastal projects. The report did not suggest specific new analysis techniques or guidelines. However, most Corps of Engineers shore protection projects have a 50-year economic life, and renourishment of most projects will typically be required several times during this 50-year period. The feasibility of future renourishments and structural improvements can be reevaluated based on any significant changes to project conditions, such as sea level rise. Monitoring of eustatic sea levels over the past few decades indicates that any such large-scale sea level changes during this period have occurred very slowly, and at this point have had no significant impact on the overall management of shore protection projects. However, a re-evaluation of any coastal engineering project should be conducted if significant changes in eustatic sea levels occur.

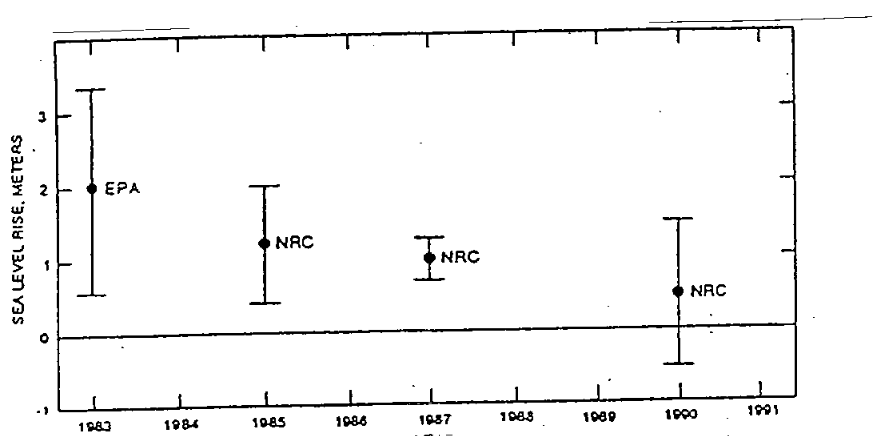


Figure 7. Summary of Predicted Sea Level Rise by Year 2100
(Houston, 1993)

Wind Data.

Local winds in the project area are the primary means of generating the small-amplitude, short period waves which impact the south Florida shoreline for much of the year. Dade County lies at 26 degrees latitude, within the edge of the tropical tradewind zone. Winds in this region originate from the easterly directions much of the year, with the greatest velocities originating from the northeast (in winter months), and the greatest frequencies of occurrence from the east and southeast (spring, summer, early fall).

Table 2 shows a summary of wind data, from WIS Station 9, located at latitude 26.0 degrees north, longitude 80.0 degrees west, offshore from the northern Dade county line. This table contains monthly summaries of windspeed and direction which illustrate the strong seasonal variation described above. From February through September, winds originate most frequently from the eastern 45-degree sector, with a stronger tendency toward the southeasterly directions from March through August. From October through January winds originate more from the northeast sector as cold fronts move through the region, usually associated with 'northeasters' of varying intensities.

TABLE 2
Wind Data Summary – Offshore Dade County

Wind Speeds – WIS Revised Phase II, Station 9

Ws (m/sec)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
0.00 – 2.49	202	177	206	249	465	553	550	519	420	246	167	158	3912
.50 – 4.99	2202	1993	2199	2302	2849	3354	3650	3613	2987	2433	1973	1922	31477
.00 – 7.49	1295	1156	1542	1389	1228	597	681	766	1051	1155	1246	1460	13566
.50 – 9.99	908	865	823	755	408	245	79	60	307	794	957	1081	7282
10.00 – 12.49	262	260	153	85	9	34	0	2	28	262	347	276	1718
12.50 – 14.99	85	68	37	15	1	17	0	0	7	68	104	61	463
15.00 – 17.49	5	1	0	5	0	0	0	0	0	2	6	2	21
17.50 – 19.99	1	0	0	0	0	0	0	0	0	0	0	0	1
20.00 +	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	4960	4529	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440

Wind Direction – WIS Revised Phase II, Station 9

45–deg wind band (center)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total	GAGE % occur. 1928–40
0.00	650	565	492	402	259	117	61	158	286	653	758	727	5128	8
45.0	1194	740	730	798	755	510	371	694	1192	1836	1529	1415	11764	17
90.0	1107	903	1061	1481	1797	1556	2295	2049	1668	1223	1224	1237	17601	23
135.0	658	676	909	781	816	1097	1102	1006	772	430	339	525	9111	28
180.0	359	479	547	421	482	633	521	418	301	159	150	237	4707	10
225.0	251	305	330	258	291	436	313	293	244	139	164	164	3188	4
270.0	282	330	364	358	312	298	204	194	176	199	213	205	3135	3
315.0	459	522	527	301	248	153	93	148	161	321	423	450	3806	7
Total	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440	100

Table 2. Wind Summary – WIS Station #9

A summary of wind directions at the right side of the bottom of table 2 shows that winds originating from the east and southeast have the highest frequencies of occurrence, with easterly and southeasterly winds occurring 23 and 28 percent of the time, respectively. However, an analysis of the top portion of the table shows that wind velocities are generally higher in the late fall and winter months when northeasters generate strong winds from the northeast sector which can last for several days per storm event.

Wave Data.

The project area on Virginia Key lies within a tidal inlet (Bear Cut) and is protected to a large degree from ocean waves. Direct wave attack from the north and south directions is limited by the sheltering effects of Virginia Key and Key Biscayne, respectively. The project shoreline is exposed to wave attack from ocean waves from the east and southeasterly directions, but the effects of these waves are greatly diminished by the extensive shoal system east of the project site. As discussed in the previous section of this report on wind data, the overall climate is moderate and as a result, locally-produced waves are generally small and low-energy relative to most of the east coast of the U.S. The south Florida area is shielded from all but the most northerly open-ocean storm swells by the Bahama Bank, and the project area is sheltered from these large swells due to its position on the south side of Virginia Key.

This section of the report will provide a discussion of the wave environment offshore of Dade County. The deepwater wave conditions will first be detailed, followed by an explanation of the processes by which the wave characteristics change as the waves propagate into shallower waters. Finally, the wave conditions at the Old County Park shoreline will be defined, for use in project design.

Offshore (Deepwater) Wave Conditions. The main cause of damages to the Dade County shoreline and to upland development are large storm waves produced by nearby tropical disturbances, including hurricanes, and by those northeasters which produce strong swells which reach the area from the most northerly directions. The extreme southerly location of the project area on the Florida peninsula usually results in weaker local effects from the passage of northeasters, since these large-scale weather systems tend to lose strength as they move further south into warmer climates, and over the warmer waters of the lower latitudes. The reverse is true for hurricanes and other tropical disturbances; Dade County lies near the center of a broad corridor of hurricane activity. Figure 8 is a plot produced by the National Hurricane Center which shows the storm tracks of hurricanes which passed within 50 nautical miles of Miami Beach between 1886 and 1980. Even though the Bahamas Bank provides a large degree of protection from distant storm swells, hurricanes which pass this close to Dade County can still produce large damaging waves across the 60-mile fetch of the Florida Straits.

The most detailed long-term database available for this region is the revised Wave Information Study (WIS) phase II wave hindcast produced by ERDC for the Atlantic coast of the U.S. This WIS record extends from 1956 through 1975, and was later appended with a data set which extends from 1976 through 1995. The latter 20-year data set includes the effects of tropical disturbances; the earlier 20-year set does not. Both data sets consist of a time-series listing of wave height, period and directions at 3-hour intervals throughout the hindcast period. The locations of the revised WIS phase II stations along the southeast Florida coast are shown in figure 9. Station 9 is located 6 nautical miles offshore of the Dade/Broward county line, at the latitude and longitude provided above. The station is in 220 meters (720 feet) of water, so virtually the entire wave record can be considered to be deep-water waves at the station location.

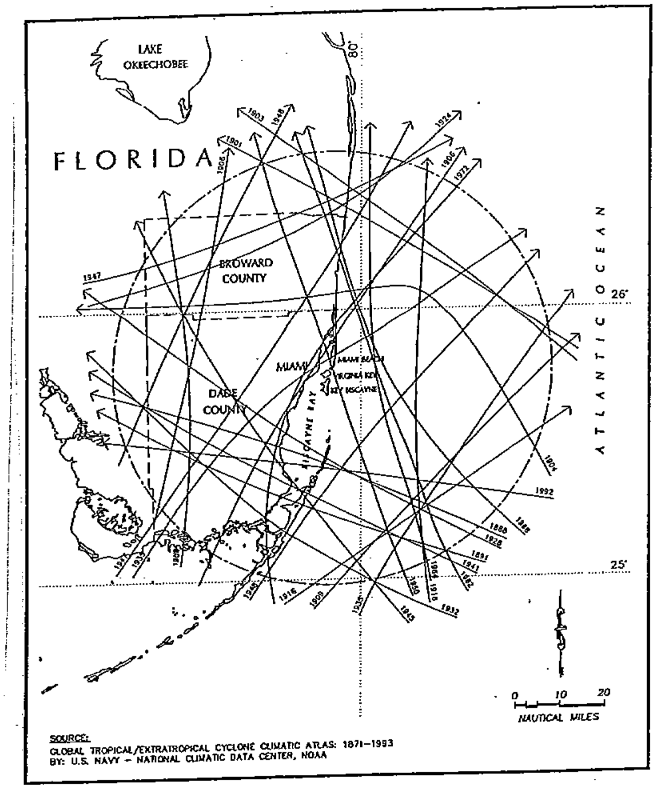


Figure 8. NHC Cumulative hurricane track plot (1886 – 1980)

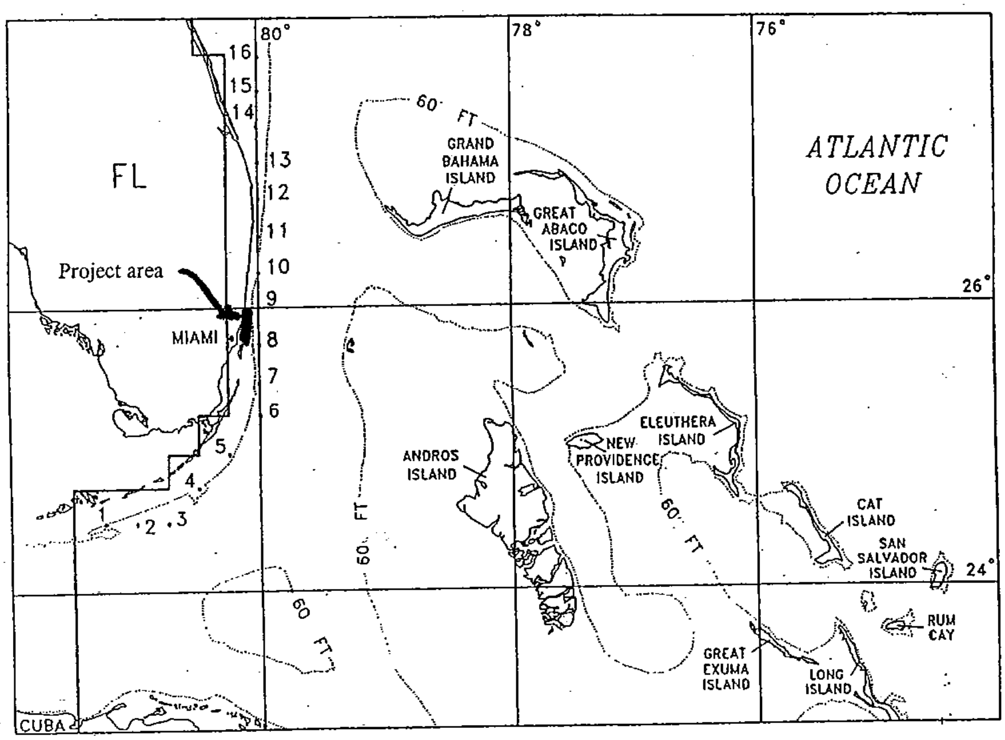


Figure 9. WIS Station 9 Location Map

This revised WIS database supercedes the original WIS phase II database by using the newer WISWAVE 2.0 numerical model to generate wave data from windfields. WISWAVE 2.0 allows the use of a finer nearshore grid, and includes more bathymetric data from the nearshore region than the original WIS phase II hindcast as well as the capability to model the sheltering effects of the Bahamas Bank, which lies directly offshore of the southeast Florida coastline. This improvement is considered essential for providing realistic wave data for the project area, as the presence of the Bahama Bank (see figure 9) prevents long-period ocean swells from reaching the Dade County shoreline from all but the most northerly directions, and limits the generation of wind waves under a wide variety of conditions.

Wave generation closely parallels the wind speed and directions discussed in the previous section, as shown in the summary of 20 years of WIS wave data at station 9 provided in table 3. These summary tables were generated from the original time-series of hindcast data from the period 1976-95. Table 3 consists of four separate tables which summarize occurrences of significant wave height (table 3a), peak wave period (table 3b), peak wave direction (table 3c), and yearly/monthly mean wave heights (table 3d) at the deepwater location of WIS station 9. All four summary tables categorize data by month, so that seasonal variations in wave characteristics can be easily observed.

The bathymetry offshore of southeast Florida is somewhat unusual for the east coast of the U.S., in that the continental shelf is at its narrowest along Palm Beach, Broward, and Dade Counties. The typical width of the continental shelf along the Dade County shoreline is about 2 miles. Due to the large degree of transformation which occurs as deepwater waves propagate from the WIS station location in 720 feet of water to breaking depths along the shoreline, two sets of wave data will be discussed. The deepwater wave database summarized in table 3 was transformed to the 12-foot depth contour using a Snell's Law routine, and the resulting shallow-water database is summarized in table 4. The 12-foot depth contour corresponds approximately to the seaward edge of the Bear Cut ebb shoal. Deepwater data summarized in table 3 will be analyzed first, then the shoaled/refracted wave event summaries contained in table 4 will be discussed.

Analyses of hindcast wave data and field observations of the wave environment along the southeast Florida coast both indicate that strong seasonal effects exist. Waves during the summer months rarely exceed 1-2 feet, and originate from the east/southeasterly directions. These locally-generated wind waves occur the vast majority of the time throughout the year, with the exception of a shift toward more frequent occurrences of larger storm-generated waves from the northerly directions during the winter months. Historically, calculated net littoral drift rates along the southeast Florida coast have indicated a net transport direction to the south, with a large northerly transport component during the summer months.

This seasonal effect is reflected in the data contained in tables 3 and 4. Table 3a provides monthly summaries of deepwater significant wave heights for the 20-year period from 1976-95, and demonstrates the seasonal variation of deepwater wave heights between the summer and winter months. During the summer months wave heights are generally much lower than in

STATION: 9

Table 3a - OCCURRENCES OF WAVE HEIGHT BY MONTH FOR ALL YEARS

Hmo(ft)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
0.00 - 1.99	1038	868	1207	1346	2038	3105	3654	3342	2250	1423	814	1041	22126	37.86
2.00 - 3.99	2308	2139	2010	2318	2110	1363	1167	1301	1952	1908	2079	2186	22841	39.08
4.00 - 5.99	1015	945	968	733	653	261	106	208	404	1087	1175	1008	8563	14.65
6.00 - 7.99	371	345	474	260	120	50	23	69	96	389	458	425	3080	5.27
8.00 - 9.99	114	128	203	94	29	19	9	14	56	112	168	206	1152	1.97
10.00 - 11.99	59	61	63	23	9	2	1	5	31	37	57	54	402	0.69
12.00 - 13.99	26	26	25	26	1	0	0	6	2	4	30	24	170	0.29
14.00 - 15.99	13	6	6	0	0	0	0	12	3	0	9	12	61	0.10
16.00 - 17.99	9	2	3	0	0	0	0	1	3	0	5	4	27	0.05
18.00 - 19.99	5	0	1	0	0	0	0	0	2	0	3	0	11	0.02
20.00 - Greater	2	0	0	0	0	0	0	2	1	0	2	0	7	0.01
Total	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440	100.00

Table 3b - OCCURRENCES OF PEAK PERIOD BY MONTH FOR ALL YEARS

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
3.00 - 3.9	161	134	209	195	368	656	938	892	354	90	119	118	4234	7.25
4.00 - 4.9	694	556	601	600	807	894	1423	1052	556	384	449	616	8632	14.77
5.00 - 5.9	861	832	759	915	922	690	710	663	650	652	894	732	9280	15.88
6.00 - 6.9	820	758	772	726	763	826	533	530	607	855	981	842	9013	15.42
7.00 - 7.9	478	497	566	399	436	443	390	438	492	648	620	550	5957	10.19
8.00 - 8.9	327	332	446	318	331	326	293	400	484	473	378	441	4549	7.78
9.00 - 9.9	285	269	244	201	303	222	173	194	443	468	290	316	3408	5.83
10.00 - 10.9	189	228	217	173	200	201	130	162	281	292	222	203	2498	4.27
11.00 - 11.9	178	112	205	213	212	221	151	147	207	224	164	151	2185	3.74
12.00 - 12.9	209	99	189	315	301	135	131	198	216	216	178	176	2363	4.04
13.00 - 13.9	147	126	194	322	147	88	54	136	196	205	130	216	1961	3.36
14.00 - 14.9	137	114	223	192	76	55	17	61	137	193	150	191	1546	2.65
15.00 - 15.9	120	91	119	89	60	28	9	37	113	112	52	164	994	1.70
16.00 - 16.9	149	144	67	68	13	10	6	21	34	66	80	80	738	1.26
17.00 - 17.9	99	117	49	20	12	5	2	20	16	39	38	55	472	0.81
18.00 - 18.9	65	56	45	16	4	0	0	8	11	21	22	40	288	0.49
19.00 - 19.9	27	22	36	27	3	0	0	1	3	11	20	25	175	0.30
20.00 - Longer	14	33	19	11	2	0	0	0	0	11	13	44	147	0.25
Total	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440	100.00

Table 3c - OCCURRENCES OF PEAK DIRECTION BY MONTH FOR ALL YEARS

Dp(deg)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
348.75 - 11.24	535	347	272	197	74	45	11	45	52	115	289	394	2376	4.07
11.25 - 33.74	980	844	548	493	474	369	184	408	787	1064	974	1166	8291	14.19
33.75 - 56.24	1495	1255	1635	1738	1556	1199	828	1265	1973	2384	1541	1609	18478	31.62
56.25 - 78.74	311	355	377	365	488	400	257	383	573	645	631	400	5185	8.87
78.75 - 101.24	396	449	512	686	870	690	1156	1093	636	357	676	474	7995	13.68
101.25 - 123.74	225	307	369	375	573	726	1062	682	315	126	265	280	5305	9.08
123.75 - 146.24	218	243	384	408	459	620	1015	636	231	98	172	161	4645	7.95
146.25 - 168.74	205	198	301	194	247	437	316	281	127	63	69	112	2550	4.36
168.75 - 191.24	139	131	172	60	107	196	63	96	80	42	49	64	1199	2.05
191.25 - 213.74	43	34	27	16	16	46	34	21	10	9	11	25	292	0.50
213.75 - 236.24	26	11	35	9	8	18	19	28	5	8	13	17	197	0.34
236.25 - 258.74	19	18	28	20	13	34	12	3	2	4	5	10	168	0.29
258.75 - 281.24	20	31	52	27	33	15	2	4	0	5	11	16	216	0.37
281.25 - 303.74	83	60	76	52	21	2	1	2	0	4	7	23	331	0.57
303.75 - 326.24	101	113	81	81	12	1	0	5	0	10	27	92	523	0.89
326.25 - 348.74	164	124	91	79	9	2	0	8	9	26	60	117	689	1.18
Total	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440	100.00

Table 3d - SUMMARY OF MEAN Hmo (ft) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1976	4.27	3.54	3.31	3.13	2.79	2.19	1.39	2.16	1.36	4.42	4.26	5.03	3.15
1977	3.76	3.34	3.62	4.93	3.12	1.36	1.73	3.07	2.02	3.01	4.53	3.96	3.21
1978	4.00	4.10	3.42	2.95	2.24	2.10	1.90	1.81	2.51	4.66	4.11	4.63	3.20
1979	5.59	4.20	4.41	4.42	3.07	2.57	2.09	1.59	4.39	2.96	5.21	4.40	3.74
1980	3.45	4.73	3.79	2.99	2.43	1.79	1.39	2.60	1.97	2.62	4.38	4.37	3.04
1981	3.37	5.57	4.68	3.57	2.28	2.18	1.54	2.67	2.59	3.47	3.82	3.25	3.25
1982	3.15	2.88	3.41	2.56	2.81	2.37	1.50	1.69	2.03	3.55	3.87	4.17	2.83
1983	2.98	4.63	3.84	3.63	2.90	1.88	1.74	1.54	3.06	3.68	3.23	4.49	3.13
1984	5.28	3.89	3.85	3.05	3.46	2.30	1.97	1.67	3.85	4.84	5.64	4.25	3.67
1985	3.21	4.58	3.53	3.49	1.80	1.70	1.75	2.25	4.36	3.37	4.37	4.11	3.21
1986	4.00	3.20	4.92	2.82	3.55	1.88	1.45	2.46	2.91	3.45	3.80	4.33	3.23
1987	3.97	3.63	5.48	2.88	2.86	2.14	2.08	1.80	1.55	4.28	4.49	3.21	3.20
1988	4.65	3.48	3.41	2.92	2.73	2.52	1.90	1.78	3.13	3.24	3.07	2.96	2.98
1989	2.95	3.18	3.41	2.44	2.07	1.81	1.48	1.46	2.46	3.04	2.44	2.78	2.46
1990	2.91	4.32	4.11	3.40	2.81	2.11	1.97	1.30	2.20	3.15	3.76	3.69	2.98
1991	2.88	3.20	3.35	3.29	3.09	1.82	1.32	1.57	1.97	3.50	3.73	3.37	2.76
1992	3.17	3.07	2.84	3.34	2.64	1.99	2.12	2.12	2.32	3.34	4.46	3.51	2.91
1993	4.30	3.75	4.03	3.58	3.15	2.40	1.35	1.79	2.37	2.57	4.09	3.55	3.08
1994	4.54	3.92	3.37	3.49	2.58	1.90	2.35	2.15	2.57	3.02	4.36	4.09	3.20
1995	3.34	3.08	4.24	2.98	2.43	2.44	2.07	2.99	2.76	4.13	3.75	3.60	3.15
MEAN	3.79	3.82	3.85	3.29	2.74	2.07	1.75	2.02	2.62	3.52	4.07	3.89	

Table 3. WIS Station 9 Deepwater Wave Summary

the winter months, and are concentrated in the lowest wave-height band in this table. During the months of August and September the overall wave energy is still low, but several large storm events are observed; these are the products of tropical disturbances. During the winter months (November to March) the overall wave energy is somewhat higher, with the majority of wave events in each month falling in the 2.0-3.99 ft range, and a greater number of large storm waves produced by winter storms ('northeasters').

On an annual basis, 77 percent of all deepwater wave events fall within the lower 2 wave height bands (0 – 3.99 feet). Of the larger wave events in the 20-year record, only 1.2 percent exceed 10 feet, and many of these events occur in August and September and are the results of tropical disturbances. An analysis of table 3a indicates that on average, the southeast Florida coast experiences a relatively low-energy wave environment year-round, but a pronounced increase in overall wave energy occurs between the summer and winter months.

Wave periods show the same seasonality as wave heights; short-period, locally-generated wind waves are common throughout the year, but in the summer months these short period waves occur almost exclusively. During the winter months a shifting towards higher-energy, longer-period storm swells can be seen in the monthly summary of occurrences of peak wave periods in table 3b. From the summary columns in table 3b, is seen that 63.5 percent of all deepwater waves fall in the peak period bands of 0-7.9 seconds, a category which is widely accepted as locally-generated 'wind waves'. Of the remaining 36.5 percent of the database, 31.7 percent of the wave periods fall within the 8.0-14.9 second band. Storm-produced swells with periods longer than 15 seconds occur in only 4.8 percent of all wave events and given their occurrences in the months of October through May, the majority of these events were very likely generated by strong northeasters.

Table 3c contains a summary of occurrences of peak wave direction during the 20-year WIS hindcast record, with the direction of wave incidence broken into 22.5-degree bands. Again seasonal effects on wave direction are noted. An examination of table 3c shows that deepwater waves originating from the east and northeast are prevalent throughout much of the year, but during July and August peak directions shift to more southeasterly directions. Again, the presence of the Bahama Bank limits the available fetch for the growth of local wind-generated waves, and prevents distant ocean swells from the easterly directions from reaching the location of WIS station 9 and the Dade County shoreline.

Table 3d provides a summary of mean wave height by month and year throughout the 20-year period of this analysis. The difference in relative wave energy between summer and winter months is easily seen in this table, both for individual years and in the summary of mean wave heights presented in the bottom row of the table. By comparing table 3a with table 3d, it is seen that the higher mean wave heights during the winter months are the result of a relatively few large storm events, and deepwater wave heights still remain below 4 feet the majority of the time. These tables again demonstrate that the overall wave energy at the deepwater location of WIS station 9 is relatively low, especially during the summer months.

Shallow-Water Wave Conditions. The wave environment differs considerably between the deepwater WIS station location and the nearshore region which is of interest in this report. Table 4 consists of a series of four tables similar to those contained in table 3, except that the wave events represented in this table have been transformed to near-breaking depths along the 12-foot depth contour, which is located along the seaward slope of the Bear Cut ebb shoal, about 1 mile east of the project area. The wave events depicted in table 4 were transformed using Snell's Law, which neglects any local effects of wave focusing caused by irregularities in the offshore bathymetry. The offshore location of WIS station 9 data is subjected to waves originating from all directions, but the nearshore location of the data contained in table 4 is subjected only to waves originating from the easterly directions due to the sheltering effect of the Dade County shoreline. Events recorded in table 3 as originating from the westerly directions are therefore recorded in table 4 as "calm" events, with a wave height of 0 feet. These calm events are excluded from the period and direction summary tables (tables 4b and 4c, respectively).

A shortcoming of Snell's Law is that no allowance is made for breaking waves. All waves higher than about 9.4 feet will break before reaching the 12-foot contour, but it is seen that many wave events much higher than 9.4 feet are recorded at the 12-foot contour in table 4a. From 2,854 to 5,662 wave events will exceed 9.4 feet in height at the 12-foot contour, depending on how many of the events in the 8 to 9.99-foot wave height band are over 9.4 feet. This constitutes from 4.9 to 9.7 percent of the total WIS wave record of 58,440 events.

Examination of data presented in table 4a shows that wave amplitudes are slightly higher at the 12-foot contour due to shoaling, but the overall seasonal effects remain unchanged. Approximately 6.4 percent of the wave record consists of the "calms" at the nearshore station which equate to the westerly waves at the offshore location of station 9. A total of 3735 westerly events occur in the WIS time series (which consists of 58,440 wave events); all of these calms were placed in the 0 – 1.99-ft wave height band in table 4a, in the months in which they occurred.

An examination of table 4 shows many similarities in the distribution of wave heights, periods, and directions as was seen in the summary of deepwater wave data presented in table 3. Wave height distributions in table 4a show the same seasonal effects as were observed in table 3a. Similar to table 3a, waves in the lowest height band dominate during the summer months (June through August), and waves in the 2 to 3.99-foot band dominate during the remainder of the year. However, a large percentage of the total number of wave events in each month falls within the lower wave height bands at both the deep- and shallow-water locations. Waves less than 2 feet in height at the 12-foot contour occur 29.5 percent of the time; waves less than 4 feet occur 63.3 percent of the time, and waves less than 6 feet occur 82.9 percent of the time. The largest storm events in the summer and early fall months are due to tropical disturbances, and the largest storm events in the late fall and winter months are due to northeasters.

WIS Station 9 Data

12ft WATER DEPTH

Table 4a - OCCURRENCES OF WAVE HEIGHT BY MONTH FOR ALL YEARS

Hmo(ft)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
0.00 - 1.99	1056	920	1086	922	1377	2389	3251	2820	1296	703	618	818	17256	29.53
2.00 - 3.99	1502	1383	1418	1749	2058	1798	1425	1500	2234	1766	1385	1518	19736	33.77
4.00 - 5.99	1155	1100	1093	1275	1015	440	223	429	866	1265	1327	1257	11445	19.58
6.00 - 7.99	553	450	460	412	308	108	31	101	185	572	649	512	4341	7.43
8.00 - 9.99	349	315	392	242	123	37	17	57	90	387	421	378	2808	4.80
10.00 - 11.99	141	147	238	90	53	15	8	20	41	140	181	235	1309	2.24
12.00 - 13.99	85	102	142	60	17	11	4	8	41	77	105	134	786	1.34
14.00 - 15.99	36	40	56	14	5	2	0	0	21	31	43	40	288	0.49
16.00 - 17.99	29	26	38	13	3	0	1	4	15	14	24	28	195	0.33
18.00 - 19.99	12	20	21	18	1	0	0	3	1	5	13	18	112	0.19
20.00 - 21.99	19	11	11	5	0	0	0	9	3	0	17	11	86	0.15
22.00 - 23.99	4	4	4	0	0	0	0	6	1	0	6	6	31	0.05
24.00 - 25.99	4	2	0	0	0	0	0	1	3	0	2	2	14	0.02
26.00 - Greater	15	0	1	0	0	0	0	2	3	0	9	3	33	0.06
Total	4960	4520	4960	4800	4960	4800	4960	4960	4800	4960	4800	4960	58440	100.00

Table 4b - OCCURRENCES OF PEAK PERIOD BY MONTH FOR ALL YEARS

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
3.00 - 3.9	61	74	106	99	273	549	871	814	333	73	78	59	3390	6.20
4.00 - 4.9	352	291	343	395	755	847	1399	1037	535	329	356	361	7000	12.80
5.00 - 5.9	682	685	644	867	905	672	708	656	632	635	831	637	8554	15.64
6.00 - 6.9	747	692	723	704	756	812	533	519	603	842	935	791	8657	15.82
7.00 - 7.9	444	478	547	392	432	441	390	433	485	635	611	550	5838	10.67
8.00 - 8.9	318	327	437	315	331	326	293	400	482	470	373	441	4513	8.25
9.00 - 9.9	280	269	231	201	303	222	173	194	443	467	288	316	3387	6.19
10.00 - 10.9	189	228	217	173	200	201	130	162	281	292	222	203	2498	4.57
11.00 - 11.9	178	112	205	213	212	221	151	147	207	224	164	151	2185	3.99
12.00 - 12.9	209	99	189	315	301	135	131	198	216	216	178	176	2363	4.32
13.00 - 13.9	147	126	194	322	147	88	54	136	196	205	130	216	1961	3.58
14.00 - 14.9	137	114	223	192	76	55	17	61	137	193	150	191	1546	2.83
15.00 - 15.9	120	91	119	89	60	28	9	37	113	112	52	164	994	1.82
16.00 - 16.9	148	144	67	68	13	10	6	21	34	66	80	80	737	1.35
17.00 - 17.9	99	117	49	20	12	5	2	20	16	39	38	55	472	0.86
18.00 - 18.9	65	56	45	16	4	0	0	8	11	21	22	40	288	0.53
19.00 - 19.9	27	22	36	27	3	0	0	1	3	11	20	25	175	0.32
20.00 - Longer	14	33	19	11	2	0	0	0	0	11	13	44	147	0.25
Total	4217	3958	4394	4419	4785	4612	4867	4844	4727	4841	4541	4500	54705	100.00

Table 4c - OCCURRENCES OF PEAK DIRECTION BY MONTH FOR ALL YEARS

Dp(deg)	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	PERCENT
348.75 - 11.24	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
11.25 - 33.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
33.75 - 56.24	28	6	12	5	17	1	17	20	3	11	23	14	157	0.29
56.25 - 78.74	1286	1075	841	782	827	705	483	782	1313	1712	1514	1530	12850	23.49
78.75 - 101.24	2405	2330	2768	2948	3065	2426	2771	2863	2965	2907	2714	2623	32785	59.93
101.25 - 123.74	495	538	753	681	837	1397	1485	1077	431	211	283	327	8515	15.57
123.75 - 146.24	3	9	20	3	39	83	111	102	15	0	7	6	398	0.73
146.25 - 168.74	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
Total	4217	3958	4394	4419	4785	4612	4867	4844	4727	4841	4541	4500	54705	100.00

Table 4d - SUMMARY OF MEAN Hm0 (ft) BY MONTH AND YEAR

YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1976	5.17	4.27	4.12	4.35	3.25	2.61	1.63	2.84	1.98	6.42	5.53	6.24	4.03
1977	5.27	3.64	4.85	6.53	3.80	1.50	1.95	3.72	2.58	3.75	6.15	5.40	4.10
1978	3.55	6.03	4.27	3.51	2.60	2.65	2.30	2.12	3.41	6.50	5.33	6.25	4.04
1979	7.48	5.33	6.04	6.20	3.96	3.24	2.53	1.83	5.67	4.05	6.88	6.08	4.94
1980	4.69	6.79	5.35	4.14	3.27	2.24	1.57	3.67	2.52	3.68	6.70	6.16	4.23
1981	3.73	7.76	7.39	4.65	2.97	2.80	1.83	2.97	3.61	4.61	5.33	3.68	4.28
1982	4.53	3.66	4.56	2.86	3.63	2.89	1.65	1.82	2.48	5.15	5.23	5.25	3.64
1983	3.18	6.32	3.50	4.01	3.48	2.23	1.99	1.67	4.11	5.45	3.97	5.64	3.79
1984	7.50	4.52	4.66	4.21	4.20	2.46	2.13	1.80	5.13	6.59	7.77	5.41	4.70
1985	3.53	6.36	4.48	5.08	2.07	1.92	2.06	2.66	5.71	4.32	6.14	5.64	4.16
1986	4.79	4.00	6.06	3.74	5.08	2.18	1.54	2.93	3.75	4.82	5.16	6.01	4.17
1987	5.22	4.27	8.06	3.24	3.49	2.46	2.48	2.30	2.24	5.43	5.55	3.91	4.05
1988	6.14	3.84	3.76	3.93	3.57	3.07	2.18	2.22	3.82	4.44	3.41	3.96	3.70
1989	3.87	3.49	4.27	3.25	2.48	2.07	1.60	1.86	3.59	4.09	2.87	3.71	3.09
1990	3.37	5.25	5.03	4.31	3.52	2.58	2.27	1.78	2.98	3.76	4.51	4.62	3.66
1991	3.14	3.03	3.43	3.99	3.74	2.48	1.38	1.91	2.71	4.68	4.52	4.22	3.27
1992	2.96	3.18	2.82	3.52	3.45	2.28	2.49	2.55	2.90	4.13	5.45	4.42	3.35
1993	5.61	4.12	5.43	4.29	4.00	2.85	1.48	2.10	3.07	3.07	5.18	4.10	3.77
1994	4.94	4.77	3.62	4.19	3.24	2.01	2.53	2.46	3.19	3.91	5.81	5.80	3.87
1995	3.12	2.86	5.02	3.62	3.15	2.61	2.12	3.91	3.64	5.21	3.88	3.47	3.55
MEAN	4.59	4.67	4.84	4.18	3.45	2.46	1.98	2.45	3.45	4.70	5.27	5.00	

Table 4. WIS Station 9 Data, Shoaled to 12-foot Depth Contour

An examination of table 4b shows an identical distribution of wave periods above 10 seconds as seen in the deepwater peak period summary presented in table 3b. A similar pattern between tables 3b and 4b is noted for wave periods below 10 seconds as well; the only difference between the two tables is caused by excluding the 'calm' westerly events from table 4b. The shallow-water summary presented in table 4b shows peak periods concentrated in the lower bands; 61.1 percent of the wave periods fall into the category of locally-produced 'wind waves' with periods below 8 seconds. An additional 33.7 percent of the wave record falls within the 8 to 14.99-second band, and the remaining 5.2 percent of events have peak periods in excess of 15 seconds. The longer wave periods generally correspond to larger wave heights, and many of the longer-period events shown in table 4b correspond to large storm waves which will break seaward of the 12-foot contour, and therefore will have less impact on nearshore littoral processes.

Table 4c shows how incident wave direction is altered as waves propagate from deepwater to shallow water depths. First, as discussed previously, all waves incident from the westerly directions are removed from the nearshore wave record since they are propagating away from the shoreline. As the remaining waves propagate through progressively shallower waters the wave directions become aligned more perpendicular to the depth contours in accordance with Snell's Law. The wave events summarized in table 4c are much more closely aligned to shore-normal than waves in greater water depths. The incident wave directions in table 3c originated from every sector but as seen in table 4c, the entire wave record is contained in five 22.5-degree angle bands, with 99 percent of the wave events contained in the central three bands.

During every month of the year, the highest number of wave events originate from the easterly sector (78.75 – 101.24 degrees) at the 12-foot depth contour. For every month, the number of waves originating from this sector is nearly double the number of waves from all other sectors combined. As seen in the summary column on the right side of table 4c, waves originate from this central (easterly) band 59.9 percent of the time, while waves from the northeast sector (56.25 – 78.74 degrees) are the second most common occurrence, at 23.5 percent. Waves originating from the southeast (101.25 – 123.74 degrees) occur 15.6 percent of the time. Waves from the more extreme north and south directions occur much less frequently : 0.3 and 0.7 percent of the time, respectively.

Table 4c again demonstrates the seasonal variations of the South Florida wave environment. The shift of incident wave directions from the east-southeast during the summer months to a more east-northeasterly direction in the winter months is easily seen in this table. From May through August waves originate from the east and southeast sectors over 80 percent of the time during each of the summer months. Waves originate from the east and northeast directions over 80 percent of the time during the remaining winter months. The resulting longshore transport rates which have been calculated along the Atlantic coast of Dade County verify this seasonal change in direction : most calculated gross transport rates are several times higher than the calculated net rates since the northerly sediment transport along the coastline during the summer months cancels out much of the southerly transport which occurs during the winter months.

Table 4d shows a summary of mean wave heights grouped by month and year throughout the 20-year period of record. It is seen that the shallow-water mean wave heights presented in this table are about 25 percent higher than the deepwater mean wave height presented in table 3d. This is in spite of the fact that 6.4 percent of the wave record has been removed and recorded as calms, since those waves propagate away from the project area. Seasonal effects are still evident however : mean wave heights average about 2 – 2.5 feet during the summer months, while mean heights of 4.5 – 5 feet are shown for some winter months. As seen in table 4a, the higher mean wave heights observed in the winter months are primarily due to a relatively small number of high-energy storm events. Table 4a also shows that the smaller-amplitude wave events occur the overwhelming majority of the time during every month of the year.

Wave Environment – Inside Bear Cut. Due the location of the project area landward of the Bear Cut ebb shoal, the influence of the waves described above on the project shoreline is greatly reduced. The maximum wave heights possible at a given location is about 0.78 times the water depth; i.e. a 5-foot wave will break in 6.4 feet of water. Depths across the extensive Bear Cut ebb shoal are shallow; nautical charts show controlling depths of 2 to 4 feet, mlw across the shoal. Elevated water levels will allow larger waves to pass over the shoal however. The largest wave which could traverse the shoal at spring high tide, assuming 4-foot minimum depths (mlw), would be (7 feet deep x 0.78 =) 5.5 feet in height. All waves larger than 5.5 feet from table 4a will break along the ebb shoal, and their wave energy will be greatly dissipated.

In practice, maximum storm waves along the project shoreline rarely exceed 3 to 4 feet, and remain below 1 foot almost 100 percent of the time. The combined dissipative effects of bottom friction on waves passing over the rough offshore coral reef system, the breaking and reforming of waves over the Bear Cut ebb shoal, wave/tidal current interactions, and the effects of refraction and diffraction created by the ebb shoal system all tend to further reduce wave heights at the project site. No wave gage or hindcast wave data is available for the area inside Bear Cut, and numerical transformation of waves from the 12-foot contour to the project site is not possible without extensive bathymetric data which is not currently available. Field observations and discussions with local interests indicate that wave energy (and the corresponding wave-induced sediment transport) is virtually always low inside the inlet.

Tidal Currents.

Current flow through Bear Cut is driven primarily by the astronomical tides, which are semi-diurnal in this area. The current directions and velocities therefore fluctuate, with two flood (incoming) and two ebb (outgoing) tides during each 24-hour period. No tidal velocities are published for the Bear Cut channel, but data published by NOAA [reference (o)] at other nearby inlets indicates that velocities of 2-3 knots (3.4–5.1 ft/sec) may occur during each tidal cycle.

The highest tidal current velocities are observed in the channel which runs through the center of the inlet. Current velocities decrease rapidly to either side of this channel. A shallow sloping shelf 300-500 feet wide exists between the channel and the project area (see survey profiles in figures 16a-d), and this feature tends to separate the highest current velocities from the project area. This shelf may offer greater protection from strong tidal currents during lower tide levels when water depths are only 1-2 feet up to 100 feet offshore. During a field inspection of the project area near low tide in December 2000, tidal currents on the order of 3-5 knots were observed well offshore of the project shoreline in the channel, but velocities along the shoreline were almost zero. During a subsequent field trip in January 2002 near high tide, velocities in excess of 1 fps were noted along the seaward tips of several of the relic timber groins. Such high velocities could pose a danger to bathers. This shelf is thickly vegetated with seagrass and is not likely to erode significantly during the project life.

The numerical model RMA-2 was set up in a previous study to investigate tidal current velocities in Biscayne Bay. The simulation area of this calibrated model included Bear Cut and the project area on Virginia Key. Maximum tidal current velocities calculated in the channel using this model were 1.5 knots (2.5 fps), while the maximum velocities near the project shoreline ranged from 0 to 0.5 knots (0 - 0.8 fps). This model was used to simulate the impacts of alternative plans of improvement on existing current velocities throughout the project area. Detailed information on this modeling effort will be provided later in this report.

Volumetric and Shoreline Position Changes.

Monitoring surveys have been performed along the three barrier islands south of Government Cut since 1867. However, construction of the Miami Harbor entrance channel at Government Cut and several subsequent modifications at Government Cut between 1902 and 1929 resulted in significant changes to the littoral processes along the barrier islands to the south of the channel. Since the Miami Harbor navigation project has an effect on the sediment supply flowing into the Virginia Key project, the most recent historical survey period (1927-60) is of particular importance because it reflects the current site conditions.

Based on surveys performed between 1927-60, the total erosion measured along Virginia Key during that 33-year period was –540,000 cy, resulting in an average annual erosion rate of –16,000 cy/yr. The rapid erosion of the beach fill placed along Virginia Key in 1969 suggests a much higher erosion rate following the fill placement. These higher losses were due to end (diffusion) losses, initial fill stabilization, and possible tidal current scouring of the exposed and unprotected fill, in addition to the 'background' erosion rate of –16,000 cy/yr. Following completion of the rubble-mound groin field in 1974, erosion of the fill placed between the groins during the first renourishment of the project was noted to be much slower. An examination of aerial photos of the Virginia Key shoreline taken since completion of the rubble groins in 1974 shows that the eastern side of the island remains stable, with little or no visible loss of fill within the limits of the Federally-constructed groin field. Erosion to the west of the rubble-mound groins is evident, particularly along the 1,300-foot gap between the rubble-mound groins and the timber groins in the Old County Park.

Sediment Transport.

A regional sediment budget was developed by Coastal Systems International, Inc. for Dade County in January 1997, based on volumetric changes along the Broward and Dade County shorelines. Large-scale monitoring surveys taken between 1980 and 1996 were analyzed, and sediment transport rates were calculated based on volumetric changes between the surveys.

Based on this analysis, it was determined that an average net volume of 24,000 cubic yards of material is transported southward along the southern Dade County shoreline every year. This material is transported into the Miami Harbor entrance channel at Government Cut, where dredging records indicate that an average of 15,000 cy/yr shoals in the interior channels, and 9,000 cy/yr shoals in the outer reaches of the entrance channel. The Government Cut jetties and channel are considered to be a complete littoral barrier – no significant natural bypassing around this inlet occurs.

A privately-funded beach renourishment project was constructed in 1990 along the 2,500-foot eastern side of Fisher Island, located between Virginia Key (to the south) and Government Cut (to the north). Monitoring of this fill indicates an erosion rate of –1,200 cy/yr. Since the net littoral drift is southward along the southeast Florida coast, some of this material may be transported across Norris Cut southward onto Virginia Key. The Fisher Island beach fill was constructed using Bahamian aragonite, so it may be possible to determine the degree of bypassing of this fill material around Norris Cut and onto Virginia Key by using the aragonite material as a tracer.

Storm History.

Several significant storm events have occurred since completion of the initial project construction on Virginia Key in 1969. Storms which occurred during this interval potentially affected the distribution of material within the limits of the project and affected project performance. These storms, consisting of several hurricanes, tropical storms, and northeasters, are described below.

1979 – Hurricane David. Hurricane David passed east of Dade County on 3 September 1979, creating a large storm swell, high winds, and heavy rainfall. As David passed the Miami area, the eye and 'strong' (northeast) side of the storm remained offshore, but large storm waves impacted the southeast Florida coast during 2 and 3 September causing localized beach erosion. David made landfall at about 6 pm on 3 September, near Melbourne, Florida.

1992 - Hurricane Andrew. Andrew was upgraded from a tropical storm to a hurricane on 22 August 1992 and struck the Bahamas on 23 August, causing widespread damage through the islands. The storm continued through the Bahamas on a near-westerly track, and made landfall as a strong category 4 hurricane about 25 miles south of downtown Miami near Homestead and Florida City, at 4:00 a.m. on 24 August. The National Hurricane Center estimated that at the time of landfall Andrew had sustained winds of 145 mph, with gusts to 175 mph. The storm center passed about 10 miles south of Key Biscayne, the southernmost point of the Atlantic shoreline in Dade County. Storm surges measured at the north and south ends of Key Biscayne were 10.1 and 10.6 feet, respectively. There were no offshore wave gages near the path of Hurricane Andrew, but a hindcast prepared by WES based on wind field data indicated that the maximum significant wave height was 22.6 feet, in water depths of 26 to 30 feet along the Miami Beach shoreline. In spite of the extreme wind, waves, and surge levels created by Andrew, damage to the Dade County Beach Erosion Control project was moderate to minimal along the length of the project, and the Federal project was attributed with saving 19.6 million dollars in upland damages.

Hurricane Andrew was classified as the third-strongest hurricane to make landfall in the U.S. in the 1900's. Total damages were estimated at between 15 and 20 billion dollars, with most of the upland structural damage resulting from high windspeeds. The normally high level of upland damage resulting from storm surge and wave impacts from landfalling hurricanes did not occur along Miami Beach and further to the north. It is believed that the relatively fast forward speed of the storm coupled with the protection provided by the Bahama Bank minimized the time that the coastline was exposed to large storm swells. These large swells apparently broke well offshore, expending most of their energy and reducing damage potential by the time they reached the shoreline. Damage to the offshore coral reefs in water depths ranging from 30 to over 100 feet was extensive, and several artificial reefs in this depth range, including large shipwrecks, were moved considerable distances by storm swells during the storm.

1995 – Hurricane Erin. Tropical storm Erin strengthened into a hurricane over the lower Bahamas on 31 July 1995. Over the next three days Erin moved northwest over the Bahamas islands chain, eventually making landfall near Vero Beach, Florida on 2 August 1995. Although direct storm effects along the Dade County shoreline were minimal, large northeasterly swells were generated as Erin crossed the deep waters of the Gulf Stream prior to making landfall in Florida. Wave data obtained from NOAA buoy 42036 shows that Erin produced waves in excess of 15 feet, with a mean wave period of 7 to 9 seconds. These northerly swells caused some erosion along the southeast Florida coast, including Dade County.

1995 – Tropical Storm Jerry. Tropical storm Jerry formed on 22 August 1995 in the Gulf Stream, between the Florida Keys and Andros Island in the Bahamas. Jerry moved in a north-northwest direction, passing directly offshore of the Dade County coast, causing strong local winds and generating high waves and minor storm surge along the Dade County shoreline. Some minor to moderate beach erosion was reported by the local sponsor.

1996 Northeaster. From 13-18 November 1996, a high pressure system off the east coast of the U.S. combined with a large low pressure system over the Caribbean Sea to generate very strong easterly winds which affected the project area for several days. Sustained winds of over 60 knots were measured throughout Dade County during this period. These winds generated wave heights in excess of 10 feet which impacted the south Florida coastline for four days, causing significant erosion to portions of the Federal shore protection project in Dade County.

1999 – Hurricane Irene. Irene formed in the western Caribbean and traveled northward over Cuba, strengthening to hurricane force in the Florida Straits. The eye of the storm passed over Key West at 0900 on 15 October and made landfall along the southwest Florida coast several hours later. Irene was a weak Category I storm at landfall, with highest sustained winds of 85 mph. The storm moved across the lower Florida peninsula, passing just to the northwest of Miami, and entering the Atlantic Ocean along the Palm Beach County coast. Although weak in intensity, Irene produced rainfall amounts up to 16 inches across south Florida, causing widespread flooding and power outages. Upon entering the Atlantic Ocean, Irene produced a large storm swell which caused some erosion of Federal shore protection projects in Dade, Broward, and Palm Beach counties.

EVALUATION OF ALTERNATIVES

General.

The primary goal of this report is to investigate methods of restoring and stabilizing the 3,400-foot length of shoreline within the Old County Park. The 1,300-foot reach of eroded shoreline at the eastern end of the Park has been substantially damaged by erosion, and currently forms a shallow embayment, as seen in figure 1. This reach of shoreline is unprotected by any structures, and is vulnerable to further erosion. The 2,100-foot reach of shoreline along the western portion of the park is protected to some degree by a partially-deteriorated existing timber-pile groin field. Increased erosion of this reach of shoreline is likely as the timber groins deteriorate further. Several alternative plans of shoreline stabilization will be investigated in this section, including the no action plan, use of beach fill, offshore breakwaters, rubble-mound groins, timber groins, and revetments.

No Action Plan.

Under the no action plan, no stabilizing structures or beach renourishment would be provided, and the shoreline within the Old County Park would be allowed to continue to erode. The minimal beach widths which currently exist along the park would be reduced further, increasing the vulnerability of upland structures to storm damage and making the beach unsuitable for recreation. Erosion would be the most severe along the 1,300 - foot gap between groin fields at the eastern end of the park, and further recession of the shoreline into the upland vegetation would occur. The condition of the timber groins would deteriorate further, rendering these structures totally ineffective in stabilizing the western portion of the park's shoreline.

Beach Fill Only.

This alternative consists of the placement of beach fill without stabilizing structures. Fill would be placed along the 1,300-foot embayment at a berm elevation +6.0 feet mlw, which is consistent with existing upland elevations in the area. The berm width would vary between 0 and 50 feet in order to construct a straight fill along this curved reach of shoreline. This variable berm configuration represents the widest berm possible with minimal seagrass coverage. An examination of front slopes of the existing subaerial beach along the park indicates an average front slope of about 1v : 10h, and it is expected that the renourished shoreline would equilibrate to a similar slope based on similarities of the fill material. Based on this equilibrium slope, the toe of the fill would intersect the existing bottom at depths ranging from +3 to –2 feet, mlw.

Historic shoreline erosion rates have been calculated at –16,000 cy/yr in previous reports, based on surveys performed between 1927 and 1960. It is anticipated that the shoreline would erode at a rate equal to or greater than this rate following construction of an unprotected beach fill, as occurred following the construction of the 1969 initial beach fill construction on Virginia Key. Several factors may contribute to higher erosion rates of an unprotected beach fill in this area. Due to the location of the fill area inside Bear Cut, some degree of tidal current scouring of the fill can be expected, and since ocean waves reach the fill area at very steep angles relative to the shoreline, a higher potential for sediment transport exists. Furthermore, the historical rate presented above is based on erosion of the natural shoreline, and the material which comprised that shoreline included large rocks and layers of stiff clay which are visible today along the eastern reaches of the park. The presence of these materials will reduce erosion rates compared to unprotected beach-quality sand, so it is very likely that the historical erosion rates are excessively low based on the presence of this existing hard shoreline material. In addition, beach fills generally tend to experience high initial losses following construction due to fill stabilization. Material is lost from the beach face as the front slope stabilizes, and large volumes of material can be lost from either end of the fill due to end (diffusion) losses, if not contained by some means. In summary, it is expected that erosional losses well in excess of the documented historical rate of –16,000 cy/yr will be observed if an unprotected beach fill is placed along this reach of Virginia Key.

Breakwaters.
Offshore breakwaters would reduce shoreline erosion by decreasing the amount of wave energy reaching the beach, thereby reducing littoral transport. The relatively shallow depths up to 500 feet offshore along the park's shoreline would make breakwater construction economical, and construction of a structure along all or a portion of the length of this eroded area would greatly reduce or eliminate incoming wave energy. A berm similar to that described above would be constructed along the shoreline landward of the structure, and would be protected from erosion by the breakwater.

However, several problems exist with construction of this alternative. First, numerical modeling as well as field observations indicate that tidal currents through Bear Cut may be responsible for a portion of the sediment movement along this shoreline. The study area is well inside Bear Cut, and is protected from deepwater ocean waves by the 2-mile wide continental shelf, the extensive shallow sandbars of the Bear Cut ebb shoal, and by the protection provided by Virginia Key and Key Biscayne from northerly and southerly waves, respectively. Additional protection from waves in an already low-energy wave climate may not be necessary.

The construction of offshore breakwaters would have little effect on these tidal currents, and may even provide a minor degree of amplification of current velocities along the shoreline depending on breakwater location and orientation. A more serious problem is the presence of extensive seagrass beds along the Virginia Key shoreline. Seagrass beds exist throughout the nearshore zone along the entire length of the park (see figure 10), including the area considered for breakwater construction. Due to the presence of such extensive seagrass beds, breakwater construction may be difficult or impossible in this area due to the large area of vegetation which would be impacted.

Groins.
The construction of groin fields has proven to be an effective means of stabilizing the Virginia Key shoreline. The existing groin fields on either side of the 1,300-foot embayment are effective at stabilizing the shoreline, and actually contribute to the erosion observed in the area between the groin fields by limiting the volume of sediment available for littoral transport. Construction of a groin field would be equally effective along this eroded area, and would provide continuity along the shoreline and match the aesthetics of the existing structures. If properly designed, these structures would provide minimal impacts to seagrass areas.

The existing groin fields on either side of the eroded area can be used as models for the design of the groins along this embayment. The rubble-mound groins to the east are about 150 feet long and spaced about 425 feet apart, while the timber groins to the west are 30 to 80 feet long and are mostly spaced 100 feet apart. The primary design objectives are to stabilize the shoreline along the park while minimizing impacts to the extensive seagrass beds in the area. In order to accomplish both goals, several alternative layouts were tested using various combinations of lengths, positions, and numbers of groins. The alternative groin field designs which were ultimately selected were based on the successful performance of the existing rubble and timber groin fields adjacent to the 1,300-foot embayment.

Two alternative groin field layouts will therefore be examined, based on the demonstrated success of the existing rubble-mound and timber groin designs in maintaining a stable shoreline along Virginia Key. The rubble-mound alternative would extend the existing rubble-mound groin field westward through the length of the park. The lengths and spacings of the new groins would be the same as the existing structures along the east side of the island : each groin would be 175 feet long, spaced 425 feet apart. Similarly, the timber groin alternative would duplicate the original design of the existing timber-groin field. Those structures vary from about 30-80 feet in length and are spaced about 100 feet apart. Some placement of beach fill would be required for either alternative in order to provide a stable beach and prevent downdrift erosion.

Revetment.
The construction of a revetment or seawall would provide an upland barrier to prevent further shoreline recession. The revetment would be constructed along the existing scarp line or vegetation line which extends along the length of the park, and would protect the upland areas behind the structure from further erosion. No protection would be provided to the beach in front of the revetment, and erosion along the shoreline may actually increase due to wave reflection off the structure. Construction of a revetment would almost certainly result in the eventual erosion of any dry beach area along this reach and since restoration of the historical recreational beach is a goal of this project, this option is not recommended.

Conclusions.
Due to the demonstrated effectiveness of groins in stabilizing the south and east shorelines of Virginia Key, and because of the benefits (and relative lack of adverse impacts) of constructing groins compared to other types of structures, the use of groins in combination with beach fill placement is selected as the most desirable method of stabilizing the eroded shoreline within the Old County Park. The use of groins will also restore the historical appearance of the park.

Specifically, two plans of structural improvement will be developed further in this Engineering Appendix : The first alternative plan of improvement consists of stabilization of the park's shoreline by constructing a rubble-mound groin field along the entire 3,400-foot length of the park's shoreline (designated "Alternative 3" in main text). The second alternative consists of stabilizing the park's shoreline by constructing a timber-pile groin field along the same reach (designated "Alternative 5" in main text). The designs of alternatives 3 and 5 would be based upon the layout of the existing rubble and timber groin fields, respectively. The no-action plan (designated "Alternative 1" in main text) will be compared to these alternatives in the Section 111 Report.

DETAILED DESIGN OF SELECTED ALTERNATIVES

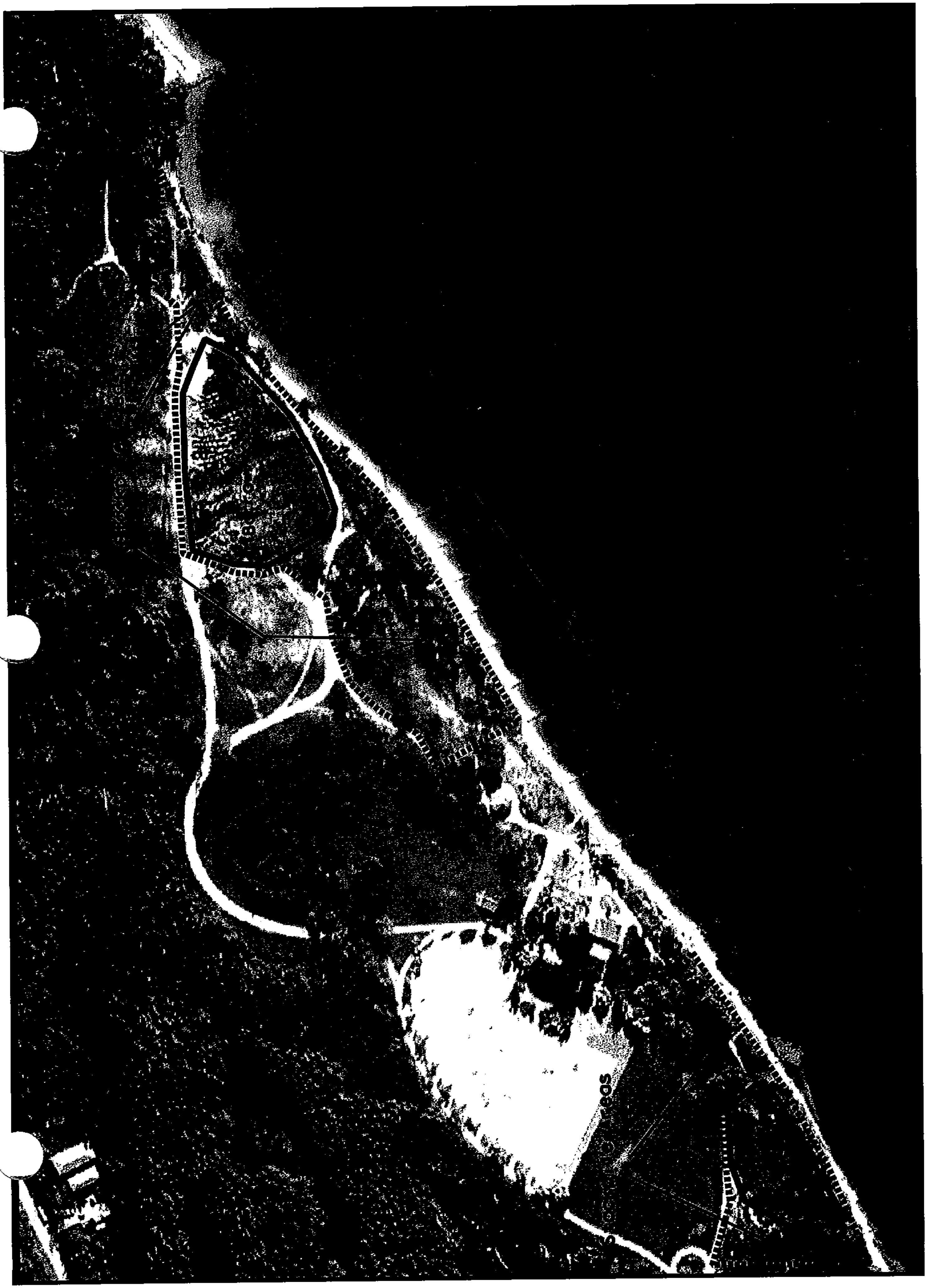
General.
Detailed designs of the proposed rubble-mound ("Alternative 3") and timber-pile ("Alternative 5") groin fields will be developed in this section of the report. Each alternative plan of improvement consists of several separate elements, and some of these elements will be identical for either alternative. Specifically, in addition to construction of either type of groin field, each of the following elements will be required, regardless of the method of groin construction:

a) Construction of a beach fill would be required along portions of the park. The source of fill will be two piles of beach-quality material stockpiled on-site from a previous dredging project. These stockpiles are located adjacent to the fill area.
b) Construction of a small dune feature at the landward edge of the constructed berm, along the 1,300-foot embayment at the east end of the park.
c) Removal and disposal of a considerable amount of debris along the shoreline will be required prior to placement of fill.
d) Removal of 26 concrete king piles (192 lf total) which were installed at the seaward ends of 10 timber groins.

For clarity throughout this report, the existing timber groins within the park will be numbered 1 through 25, extending from east to west, as shown in figure 1. Each of the proposed alternatives includes the construction of several new groins. All new groins in each alternative plan of improvement will be lettered "a", "b", "c", etc, also extending from east to west. Beach fill will be placed in the spaces or 'cells' between the new or restored groins. Beach fill locations will be designated by cell number, also extending from east to west.

Due to the presence of shallow water depths and extensive seagrass beds near shore, all construction activities for each alternative will be limited to land-based methods along the entire length of the park. Any operations which generate turbidity will be strictly controlled to prevent additional seagrass damage. An existing network of paved and dirt roads extends along most of the 3,400-foot length of the park, and will provide full access for construction equipment. In addition, sand ramps may be constructed over the existing groins to allow equipment access over these structures, but these ramps must be removed and pre-project grades re-established following completion of the project. The park is intermittently opened to the public, so for public safety the stockpile and construction areas adjacent to the shoreline will be fenced off prior to commencement of construction. The stockpile areas, borrow areas, and access roads are shown in figure 11.

The general construction methodology relating to the elements that both alternative plans of improvement have in common (i.e. placement of the beach fill and borrow area usage, debris removal, for removal of the king-piles) will be discussed first. Then detailed designs will be developed for each method of groin construction. The total costs for constructing Alternative 3 and Alternative 5 (including all elements) will then be presented at the end of this section.



Beach Fill Design.

General. Both alternative plans of improvement will include some amount of beach fill placement, but the layout of the beach fills proposed in alternatives 3 and 5 will differ due to the different configurations of the proposed groin fields. The specific design of the beach fill component of each alternative will be discussed in the following sections of this report detailing the design of each groin field layout. This section of the report provides general data on the design process for the two beach fill layouts, on the source of borrow material, construction methods, and preparatory work required at the beach fill site.

Beach Fill Layout. In designing beach fill layouts for each alternative it was assumed that sediment would stabilize under the influences of waves and currents into the same general plan-view shapes observed in the adjacent groin fields. For example, the patterns of sediment accumulation observed along the existing rubble-mound groin field were used as a basis for designing the beach fill layout included in alternative 3 (see figure 13), and the patterns of sediment accumulation between the timber groins were used as a basis for designing the beach fill included in alternative 5 (see figure 15). It was further assumed that sediment would bypass around the seaward ends of these structures in a manner similar to the patterns observed along the existing timber and rubble-mound groin fields.

In both alternative plans of improvement, fill would be placed in a variable berm-width configuration to approximate the equilibrium shape of the beach, based on the shape of the existing pocket beaches within the rubble-mound and timber-pile groin fields. By designing the beach fill to approximate the equilibrium shape of the beach the volume of sediment transport following construction can be reduced greatly, minimizing erosional losses from the project and decreasing the risk of covering additional areas of the nearshore seagrass beds. The design berm elevation of +6.0 feet mlw for either alternative corresponds to the originally-authorized project berm elevation, and also corresponds to existing upland elevations along the park. A front slope design of 1v : 10h was selected based on the natural slope of the existing beach and similarities of the fill material to the native sediment.

The specific design of the limits of fill for each alternative were determined by an interactive procedure in which various groin layouts were combined with the corresponding stable sediment accumulation patterns, and compared to the limits of seagrass coverage. Details of the specific beach fill designs for alternative 3 and alternative 5 are presented in the following sections of the report which discuss the groin field design for each alternative.

Source of Fill Material. The primary borrow area for beach fill construction ("sand mound #2") is located adjacent to the shoreline at the east end of the park, and a smaller secondary borrow area ("sand mound #1") is located adjacent to the shoreline at the western edge of the park, as shown in figure 11. Both borrow areas consist of large mounds of material dredged from near Key Biscayne which were stockpiled in these locations along the Virginia Key shoreline. The primary borrow area contains approximately 60,000 cubic yards of material, and the secondary borrow area contains approximately 12,000 cubic yards of material. The borrow material from each area is slightly finer than the existing beach material and contains about eight percent silt.

Some rock and shell fragments are also observed in the two borrow sites, but the material has been determined to be compatible with the sediment on the existing beach along Old County Park.

Due to the proximity of the primary borrow area to the fill area (several hundred feet or less) and due to the adjacent environmentally sensitive seagrass areas, fill will be transported and placed using mechanical means such as front-end loaders, dumptrucks, and/or bulldozers. Hydraulic placement of fill is not allowable due to the adverse impacts on seagrass beds from the high turbidity levels which would be created by the outflow of the dredge slurry. Because of the similar characteristics between the borrow material and the native beach sediment, it was assumed that the beach fill would stabilize at a 1v:10h front slope, based on an analysis of existing front slopes along Virginia Key. Since beach fill will be placed mechanically, the front slope can be constructed at this equilibrium slope of 1v:10h, and minimal slope adjustment should occur.

Due to the configuration of the beach fill in the cells between the new groins, the order of work will specify that groin construction must be completed before beach placement begins. The only exception is that the contractor may opt for partial placement of the beach fill as a means of accessing the seaward portions of each groin during construction of these structures. In this case sand ramps would be constructed along each groin alignment to allow equipment access to the seaward portions of the groin construction sites. All fill placed in this manner would be required to remain within the limits of allowable beach fill placement shown in figures 13 and 15.

Following completion of the beach fill, a small dune will be constructed along the landward edge of the berm along the eastern portion of the park. The dune will be 2 feet high with a 2-foot crest width and 1v:5h side slopes. The dune will be built in five 150-foot segments (930 feet overall), with 20-foot gaps between segments for beach access. A total volume of 710 cy of fill from either of the two borrow mounds will be used for dune construction. The dune will be built using land-based earthmoving equipment in a manner similar to the construction of the beach fill.

Site Preparation. Prior to construction of the beach fill, various debris will be removed from the fill area, primarily along the eastern 1,300 feet of the park's shoreline. Erosion of that shoreline has resulted in the accumulation of numerous downed trees, exposed stumps, and large rocks which must be removed prior to construction of the beach fill. A view of some of the debris along this reach of shoreline is shown in figure 5a. This debris will be hauled to an upland area of the park and sorted for disposal. All wood, plastic, and metal debris will be disposed of in a county landfill; all rock debris will be set aside for use in the county's artificial reef program.

Large areas of stiff clay and peat lie exposed along the eastern 1,300 feet of the park, and beach fill will be placed directly over these outcroppings. Several areas of loose rock also lie exposed along this reach of the park's shoreline, including the scattered remains of two relic rubble-mound groins. The stones from these two structures are approximately 1 – 2 feet in diameter and will be removed prior to fill placement and stockpiled for possible reuse as artificial reef material as described above. Any other stones greater than 1 foot in diameter lying within the footprint of the beach fill or in the nearshore region will also be removed and stockpiled. The majority of the stones which lie scattered along the beach are less than 6 inches in diameter, and will not be removed prior to fill placement.

Future Maintenance of Beach Fill. No beach fill maintenance has been required along the Federally-constructed fill on the east side of Virginia Key since completion of the project in 1974, or along the existing timber-groin field within the park, which was constructed in the 1948 and 1956. Currently these regions of the shoreline remain in good condition, and no future beach fill placements appear necessary in these areas at this time. It can be assumed that similar beach fill performance will result from the construction of alternatives 3 and 5. Based on the demonstrated ability of the existing rubble-mound and timber groin fields to maintain a stable shoreline for at least 26 and 50 years, respectively, no periodic renourishments of the project shoreline are anticipated. Future maintenance costs of the beach fill over the 50-year period of economic analysis are therefore calculated to be zero.

Removal of Concrete King Piles.

Each of the proposed alternatives require the extraction of the existing concrete king piles. Ten groins near the center of the existing timber groin field were lengthened a total of 192 linear feet in 1965 by installing 26 concrete king-piles. Each king pile is 2 feet x 2 feet in cross-section, and extends about 5 feet above mlw. Each pile contains vertical slots or grooves along the sides in which horizontal timbers can be placed to form a solid barrier. King piles were driven seaward of timber groins #6, 7, 9, 11, 12, 13, 14, 15, 16, and 17 at 12-foot intervals, and horizontal 3"x8" timbers were placed in the slots to lengthen each of these groins by either 12 or 24 feet. All timbers connecting the king piles will also be removed. A photograph of a typical king-pile groin (groin #13, with 24-foot king-pile extension) is shown in figure 12. Most of the horizontal timbers between the three king piles have remained intact on this particular structure. A total of 26 piles were driven in 1965, and each of these structures is to be removed.

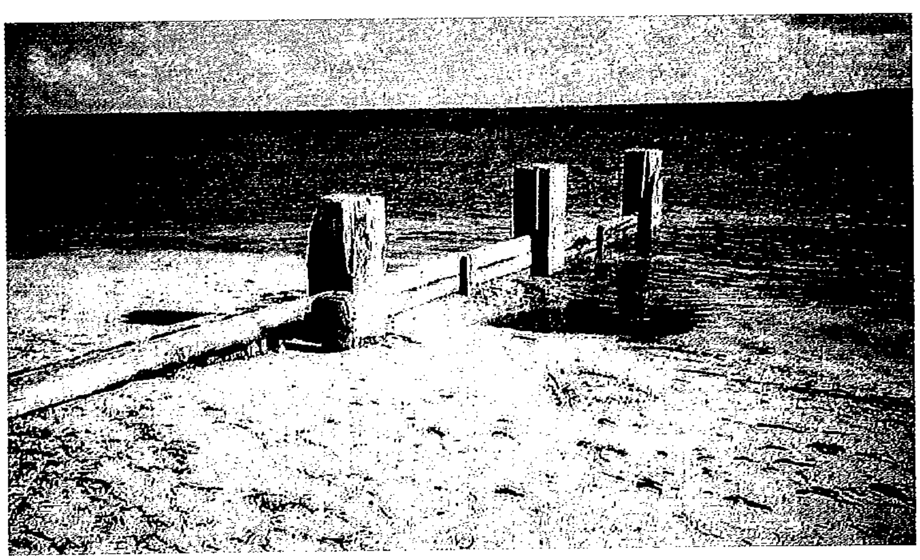


Figure 12. Photograph of King-Pile Addition to Timber Groin (Groin #13)

Subsurface geotechnical investigations along the portion of the project where the king piles are to be removed indicate that the sediment in this region consists of medium dense, poorly sorted sand to depths of 17 to 22 feet overlying limerock. This material should present no significant problems with removing the king piles. No data is available to provide the depth to which the king piles were driven, but it is believed that each pile extends no deeper than 15 feet into the ground, since this is the same penetration used for the piles which support the timber groins, and is consistent with current design standards. Based on these types of sediment and the weight of the piles, a 50-ton crane should be more than adequate to remove the piles. Table 5 provides a listing of the number of king piles present at each of the 10 extended groins, and the distance (in December 2000) from the mlw line to the farthest pile offshore at each groin. As seen in this table, the maximum distance from mlw to the farthest king pile is about 25 feet at low tide, at groin #9. Two additional groins require 20-foot reaches.

Table 5
Summary of King Pile Groins to be Removed

Groin #	# of King Piles Present	Dist. offshore, from mlw
6	2	5'
7	3	10'
9	2	25'
11	2	20'
12	2	20'
13	3	15'
14	3	5'
15	3	dry
16	3	dry
17	3	dry

Table 6 provides a summary of the distances (December 2000) of each of the 26 king piles from the mlw line. From this table it is seen that many piles lie offshore very close to the mlw line, but the greatest number of piles lie upland of mlw, on the dry beach at low tide. Most types of construction equipment which would be used for pile extraction can be positioned at or near the mlw line, so the data in tables 5 and 6 provide an indication of the reach required to extract the piles. The lifting capacity of any crane is dependent on the boom angle, so the closer the crane can be positioned to the pile, the more vertical the boom can be raised, and the greater the lifting capacity of the crane.

Table 6
Summary of King Pile Locations Relative to MLW Line

Distance from mlw line, ft	# of piles
Above mlw	13
0-5' seaward of mlw	5
5-10'	1
10-15'	3
15-20'	3
20-25'	1
> 25'	0

The seagrass beds extend landward to the mlw line along most of the reach of shoreline between groins #6 and #17, so no construction of sand ramps or any type of structure will be allowed in order to bring construction equipment closer to the piles. The construction of sand ramps to allow construction equipment over the landward portion of the groins is allowed, providing that the ramps are removed and pre-project grades are re-established along the beach following project completion.

The use of vibrating pile extractors will be allowed to facilitate the removal of these structures. In the event that some piles cannot be removed, upon the direction of the Corps representative the pile may be cut at a minimum of two feet below ground elevation. Turbidity curtains would be placed around the pile during excavation and cutting to minimize damages to the surrounding seagrass areas. Cutting of piles would be allowed only if all other reasonable methods of extraction fail. The extracted king piles and any connecting timbers are to be stockpiled in separate areas within the park for future use by the local sponsor.

The construction of the beach fill and dune, the debris removal, and the removal of the king piles as described in the preceding sections are all elements which will be included in both alternatives 3 and 5. The beach fill dimensions will vary between the two alternatives, while the dune construction, debris removal, and removal of the kingpiles will be identical regardless of which alternative is chosen. The main difference between alternative #3 and alternative #5 is the design of the groin fields, which will now be discussed.

Design of Rubble Groins (Alternative #3).

Groin Field Layout. The existing Federally constructed rubble-mound groin field has proven to be very effective at stabilizing the shoreline along the east side of Virginia Key. Prior to construction of this groin field this area experienced very high erosion rates; following construction of the groin field in 1974 the shoreline has been stabilized to the point that no further renourishments have been required.

Based on the proven success of this design, the first alternative plan of improvement (designated "alternative #3" in main text) is a continuation of this rubble-mound groin field westward through the length of the park. Based on the dimensions of the existing rubble-mound groin field, the new structures would be 175 feet long, spaced 425 feet apart. As seen in figure 13, this layout results in the construction of eight structures (1400 lf total). Two new groins would be constructed along the 1,300-foot gap between the existing groin fields and six older timber groins would be replaced with the rubble-mound design as shown in the figure. The 25 existing timber groins (including king piles) would all be removed and the shoreline cells between each new rubble-mound groin would be backfilled to provide a stable beach and prevent downdrift erosion.

Each of the eight rubble-mound groins constructed under this alternative would be similar to the design used in the 1974 construction of the Federal groin field on the east side of the island (see figure 2). The two new 175-foot groins at the east end of the park would be constructed at 425-foot spacings at the locations shown in figure 13. Then the 25 existing deteriorated timber groins would be removed and rubble-mound groins 1 through 6 would be rebuilt along the previous alignments of timber groins #1, 5, 9, 14, 19, and 24. Each of these six rebuilt groins would be 175 feet long, and the structures would be spaced an average of 425 feet apart as shown in figure 13. All groin orientations are shore-normal, and each groin extends landward to about 10 feet past the existing escarpment and/or vegetation line to prevent breaching around the landward end of the structures. The seaward end of each of these structures will extend into the seagrass beds.

Each of the eight shoreline cells between the eight new groins would be backfilled following groin construction to stabilize the shoreline and to prevent downdrift erosion. Fill will be placed in a variable berm-width configuration as shown in figure 13 to approximate the equilibrium shape of the beach based on the shape of the existing pocket beaches between the existing rubble-mound and timber-pile groin fields. By designing the beach fill to approximate the equilibrium shape of the beach the volume of sediment transport following construction can be reduced greatly, minimizing erosional losses from the project and decreasing the risk of covering additional areas of the nearshore seagrass beds. The design berm elevation of +6.0 feet mlw corresponds to the originally-authorized project berm elevation, and also corresponds to existing upland elevations along the fill area. The total volume of material required to construct the beach fill as shown in figure 13 is 30,500 cubic yards. The volume of beach fill to be placed in each of the eight shoreline cells between the new rubble-mound groins is shown in table 7. This table also shows the length of each shoreline cell and the area of seagrass coverage along each cell. An additional 710 cy of fill will be placed to form the dune feature along the eastern reach of the park, as previously described.

The proposed groin field for Alternative 3 therefore consists of eight rubble-mound structures (1,400 linear feet of structure), spaced at roughly 425-foot intervals along the entire 3,400-foot length of Old County Park. Beach fill will be placed along the length of the park and the dune feature would be constructed along the eastern portion of the park following completion of the groins. Examination of the performance of the existing groin field on the east side of Virginia Key verifies that the proposed groin field configuration described above should be effective in stabilizing the entire 3,400-foot length of the park.


EXISTING TIMBER GROINS
(TO BE REMOVED)

	Cell #1	Cell #2	Cell #3	Cell #4	Cell #5	Cell #6	Cell #7	Cell #8	TOTAL
Length of Fill (ft)	425	425	425	425	425	425	425	425	3,400
Volume of Fill (cy)	4790	5750	6090	2975	3425	3990	1740	1740	30,500
Seagrass Coverage (sq.ft)	6360	12015	18320	13880	17530	22645	14355	17035	122,140

Table 7
Beach Fill Design - Alternative #3

Details of Rubble-Mound Groin Construction. The eight structures described above would be constructed using a rubble-mound design similar to the structures already in place along the eastern side of Virginia Key. The crest elevation of these new structures will be +5 feet, mlw, which provides a transition between the existing crest elevations of +6.5 feet for the rubble-mound groins to the east, and the successful +4.0-foot crest elevation of the timber groins along the western section of the park. This lower crest elevation was used for the timber groins along Old County Park due to the greater degree of wave sheltering within the inlet. The cross-section of the rubble-mound structure is shown in figure 14. The median armor stone size is 1200 lbs, with side slopes of 1v : 2h.

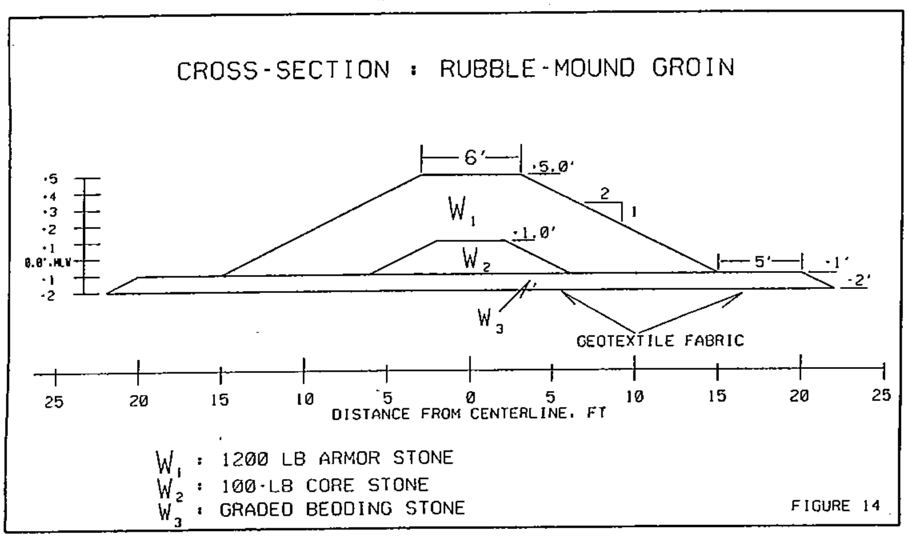


Figure 14. Cross-Section of Proposed Rubble-Mound Groin.

A core layer is provided to decrease the permeability of the structures. The core layer will consist of 100-lb stone, with a crest elevation of +1 foot, mlw. The bedding layer will be 1 foot thick, with a bottom elevation of –2 feet, mlw. Geotextile fabric will be placed under the full width of the bedding layer. Each of the stone layers will be constructed using locally-mined limerock, with a density of not less than 145 pcf. A potential disadvantage of using the rubble-mound groin design is the large footprint of the structures. As seen in figure 14, this design results in a foundation width of 44 feet. Since the eight groins extend a total of 842 feet into the seagrass bed, an area of seagrass of 37,050 square feet would be covered by these structures.

Placement of the proposed beach fill would cover an additional 122,140 square feet of seagrass, so the total area of seagrass impacted by construction the groins and beachfill proposed in alternative 3 is 159,190 square feet, or 3.65 acres.

The quantities of materials required to construct the two new rubble-mound groins and six rebuilt groins are provided in table 8 below. The required quantities are itemized for each groin, with the total quantity of each material listed in the right-hand column of the table. Materials would be stockpiled in the adjacent fields, shown in figure 11. Since land-based construction is required, the full length of each groin would be constructed by either driving construction equipment along the top of each groin as construction progresses, or by placing beach fill along each structure (within the allowable footprint of fill placement) and driving construction equipment over the fill. Curtains will be required to contain turbidity generated by excavation and other related construction activities. The total estimated cost of constructing alternative 3, including construction of the groin field and beach fill as described above, and all related activities, is $5,242,700. Details of the cost estimates are provided in sub-appendix A-1. Based on observations of the performance of the existing rubble-mound groin field on the east side of Virginia Key, no maintenance of these eight rubble-mound groins or beachfill will be required, and future maintenance costs will be zero.

Table 8
Quantities of Material Required : Rubble-Mound Groin Field
(Alternative #3)

Groin	Length,ft	Armor Stone,tons	Core Stone,tons	Bedding Stone,tons	Geotextile Fabric,sy	Excavation,cy
A	200	1100	180	440	980	750
B	200	1100	180	440	980	750
1	200	1100	180	440	980	750
2	200	1100	180	440	980	750
3	200	1100	180	440	980	750
4	200	1100	180	440	980	750
5	200	1100	180	440	980	750
6	200	1100	180	440	980	750
TOTAL	1600	8800	1440	3520	7840	6000

Design of Timber Groins (Alternative #5).

Groin Field Layout. This plan of improvement proposes the use of timber-pile groins as an alternative to the rubble-mound construction described above. The existing timber groin field has been in place since the 1940's and 1950's with very little shoreline erosion occurring along this area during that time. Similar to the methodology used above for the design of the rubble-mound structures, alternative #5 will be based heavily on duplicating and restoring the successful design of the existing timber groin field along the entire length of the park.

The 25 existing timber groins vary in length from 30 to 80 feet, and most of these structures are spaced 100 feet apart. The restoration of the timber groin field will be based on rebuilding these structures to their original dimensions, using the same design shown in figure 3 for the original project construction. In order to minimize environmental impacts and maximize the effectiveness of the structures, three modifications to the groin field layout are recommended. First, the timber portions of several groins extend into the seagrass beds, and it recommended that these portions of the groins be removed to minimize environmental impacts. Secondly, removing the concrete king-pile sections of the timber groins will shorten some groins to the point where they are no longer effective, and it is recommended that these groins be extended seaward to replace some of the length of the king pile sections while remaining clear of the seagrass beds. Thirdly, the landward ends of several groins should be extended further upland to prevent flanking. The landward portion of several groins remain buried and it was not possible to determine the landward limit of these structures. In order to prevent flanking all groins should be extended landward to the vegetation or scarp line. More detailed information on specific modifications to each of the 25 timber groins is presented in table 9 of this report.

In addition to the restoration of all 25 existing timber groins within the limits of the park, new groins would be constructed at the east end of the park to stabilize the shoreline along the 1,300-foot gap between the existing groin fields. The shoreline along this gap is badly eroded and currently forms a shallow embayment in which the shoreline has receded by as much as 175 feet, as shown in figure 1. Several combinations of groin spacings and lengths were tested along this embayment in order to provide maximum shoreline stability and a minimum amount of seagrass coverage.

Design of New Timber Groins. The lengths of the new groins were designed based primarily on sediment accumulation patterns along the adjacent groin fields. It was assumed that sediment would stabilize under the influences of waves and currents into the same general plan-view shapes observed in these adjacent groin fields. It was further assumed that sediment would bypass around the seaward edge of each of these impermeable structures in a 10-foot wide band, based on observations at the existing timber groins. In order to determine the design lengths of each groin, CADD software was used to overlay the DERM seagrass delineation onto a recent project aerial photograph. Groins of varying lengths were then overlaid onto this aerial photograph with corresponding stabilized beach fill configurations in order to determine the lengths of structures required to maintain a stable shoreline. Where possible, a minimum distance of 10 feet was maintained between the end of the groins and the landward edge of the seagrass bed, to reduce the environmental impacts due to sediment bypassing around the structures.

The optimum layout of the new structures from this analysis consisted of three new timber groins, spaced roughly at third-points (325 feet) along this 1,300-foot embayment. This spacing provides a smooth transition between the 425-foot spacing of the existing rubble-mound groins to the east, and the 100-foot spacing of the existing timber groins to the west. These groin locations also correspond to natural gaps in the seagrass bed, so environmental impacts would be minimized. The structural design of the three new groins and the 25 rehabilitated groins will all be identical to the originally-constructed timber groin design shown in figure 3.

The three new groins are designated alphabetically from east to west, and are described as follows :

Groin "A" is located 350 feet westward from the westernmost rubble-mound groin, and is 100 feet in length.

Groin "B" is located 285 feet west of groin "A", and is 120 feet in length. This structure is slightly longer due to its location in the center of the embayment.

Groin "C" is located 325 feet west of groin "B", and is 130 feet in length. Groin "C" was placed in this position to minimize seagrass impacts, but the structure still extends about 35 feet into the seagrass bed. The distance from groin "C" to the easternmost existing timber-pile groin is about 340 feet.

Restoration of Existing Timber Groin Field. During a site inspection at low tide in December 2000 it was noted that each of the existing timber groins was almost totally deteriorated below the mlw line, and substantial deterioration had occurred in the intertidal zone, between mlw and mhw. The upland portions of each structure (above mhw) appeared to be in satisfactory condition, but most of the upland portion of each groin was buried, so an accurate appraisal of the condition of the entire structure was not possible. Due to uncertainties as to the condition of the buried upland portions of the existing timber groins, two methods of rehabilitation will be examined: complete removal and replacement of the total length of all 25 structures ("Alternative 5a"), and repair of the damaged groin sections only ("Alternative 5b"). Both of these alternatives are shown in figure 15.

During the December 2000 site inspection several field measurements were made along each groin, including the total length of each groin, lengths of timber and kingpile sections of each groin, length of damaged sections, and distance each groin extends into the seagrass bed. All measurements include the lengths of the concrete king pile sections. These field measurements are tabulated in the left side of table 9.

The right side of table 9 presents the recommended improvements to each existing timber groin as described above. These changes include the number and corresponding length of king piles to be removed, the amount that the seaward end of each existing timber groin will shortened (to remain clear of seagrass) or lengthened (to partially restore the length of some king pile sections), and the landward extension of selected groins (to prevent flanking). The two shaded columns on the right side of table 9 show the total length of timber groins to be repaired (alternative 5b), and the total length of timber groins to be completely removed and replaced (alternative 5a). Note that the groins would be extended further landward only in alternative 5a; it is assumed based on site inspections that the buried landward portions of the timber groins (to remain in place in alternative 5b) are in acceptable condition and extend far enough landward to prevent flanking.

Table 9
Timber Groin Data

Timber Groin #	Total visible length of groin(ft)	Length of timber sections (ft)	Length of kingpile sections (ft)	Max distance into seagrass(ft)	Length of damaged timber sec's(ft)	Length of kingpile grn tb removed(ft)	Number of kingpiles tb removed	Length of seaw'd end of timber grn t.b.shortened(ft)	(Alt 5b) Length of timber grn t.b. repaired(ft)	Add'l length added to landw'd end	(Alt 5a) Length of timber grn t.b. rebuilt(ft)
TG1	50	50	0	20	40	0	0	20	20	30	60
TG2	50	50	0	0	50	0	0	0	50	20	70
TG3	50	50	0	0	30	0	0	0	30	20	70
TG4	50 *	50	0	0	40	0	0	0	40	10	60
TG5	50 *	50	0	0	10	0	0	0	10	10	60
TG6	62 *	50	12	5	20	12	2	0	20	0	50
TG7	74 *	50	24	5	20	24	3	0	20	0	50
TG8	50	50	0	10	40	0	0	10	30	20	60
TG9	72 *	60	12	25	40	12	2	20	20	20	60
TG10	80 *	80	0	30	40	0	0	30	10	20	70
TG11	72 *	60	12	20	40	12	2	10	30	20	70
TG12	62 *	50	12	15	30	12	2	10	20	20	60
TG13	54 *	30	24	15	10	24	3	0	10	20	50
TG14	44	20	24	5	0	24	3	(10)	10	10	40
TG15	54 *	30	24	0	0	24	3	(10)	10	0	40
TG16	44 *	20	24	0	0	24	3	(10)	10	0	30
TG17	44 *	20	24	0	0	24	3	(10)	10	0	30
TG18	40 *	40	0	0	10	0	0	0	10	0	40
TG19	30 *	30	0	0	10	0	0	0	10	0	30
TG20	30	30	0	0	10	0	0	0	10	0	30
TG21	30	30	0	0	10	0	0	0	10	0	30
TG22	30	30	0	0	10	0	0	0	10	0	30
TG23	30	30	0	0	10	0	0	0	10	0	30
TG24	40	40	0	0	20	0	0	0	20	0	40
TG25	30	30	0	0	10	0	0	0	10	0	30
TOTALS:	1222	1030	192		500	192	26	100	440	220	1190

* Denotes that landward end of groin is buried, and additional 10' timber sections may exist further landward.
( ) Indicates groins where timber sections will be extended into regions where concrete king piles were formerly located

As seen in table 9, alternative 5a (reconstructing entire groin field) involves the permanent removal of a total of 192 lf of king pile groins, plus the temporary removal of the entire 1,030 lf of existing timber pile groins. It is important to note that the landward extent of many timber groins is still unknown (shown by asterisks in table 9) and the length to be removed may increase if additional buried portions of the groins are uncovered once excavation and removal of the structures begins. Under the provisions of alternative 5a the timber groins would be rebuilt using the original timber-pile design. The original length of the timber portion of each groin would be completely rebuilt, with the following exceptions. Six timber groins would be shortened by a total of 100 feet in addition to the permanent removal of the concrete king piles, in order to remove all groin structures from seagrass areas. The timber sections of groins 14 through 17 would be lengthened by 10 feet each (into the region previously occupied by king piles, but clear of seagrass) in order to more closely match the seaward limit of the surrounding groins. A total of 220 lf would be added to the landward end of 12 groins to ensure that the structures are firmly anchored into the uplands, to prevent flanking. A total of 1,190 lf of timber groin would be rebuilt under the provisions of alternative 5a.

Construction of alternative 5b (repairing only damaged portions of groin field) would similarly require the removal of 192 lf of king pile groin sections. Only the damaged portions of the timber groins would be removed, currently estimated at a total of 500 lf among 21 of the 25 timber groins. As in alternative 5a, the seaward portions of six timber groins would be shortened by a total of 100 feet to remain clear of seagrass beds. The lengths of groins 14 through 17 would also be extended seaward by 10 feet each, as in alternative 5a. The landward portions of the existing 25 groins would not be extended further upland; the existing buried portions of the timber groins are assumed to provide adequate protection against flanking based on past performance. A total of 440 lf of timber groin would be repaired under the provisions of alternative 5b.

Selection of Materials. Several types of timber material were investigated for use in the construction of these three new groins, and for the rehabilitation of the 25 existing groins. Creosote-coated timber was used in the original construction of the timber groin field, but due to current environmental regulations this material cannot be used for the groin construction and repairs proposed in this study. The use of CCA (Chromated Copper Arsenate) timber has replaced creosote-coating, and will be investigated in this report. The use of 'greenheart' wood from South America and the use of synthetic timber materials made primarily from recycled plastics were also considered in this report. Other materials such as concrete, steel sheet pile, etc were not acceptable to the local sponsor due to aesthetic concerns. In determining which material would be the most effective and cost-efficient, the advantages and disadvantages of each material were noted.

The wetted portions of the original creosote-coated timber groins remained intact for at least 15-20 years, and the upland portions of the structures which are visible still appear to be in good shape today – over 50 years after the first groins were constructed. Replacement of the creosote-coated timber with CCA-treated timber is recommended about every 15-20 years if the material is submerged (below mlw) or subjected to wetting and drying (intertidal zone). Greenheart wood requires less maintenance, but the initial cost is much higher. Periodic maintenance and replacement would still be required, although on a less-frequent basis than for CCA-treated timber. Problems with acquisition of this type of timber may be encountered from the provisions of the "Buy American Act" since this material is produced only in South America. Since no local supplier exists no cost data is available, and due to restrictions on imports created by the Buy American Act, the use of this material is not recommended.

The use of synthetic material also has a higher initial cost, but lower maintenance costs. The primary disadvantage of using synthetic material is that the material is generally much more flexible than wood and cannot easily be driven into the ground. A review of figure 3 shows that the main support piles and the vertical 3"x8" timber slats are each driven a minimum of several feet into the ground. Synthetic piles are not produced, and in any case neither the piles nor slats could be driven into place. Digging or jetting the materials into position would generate excessive turbidity near the seagrass beds, so the use of synthetic material was considered impractical and not considered further. Therefore, due to the disadvantages of using greenheart lumber and synthetic materials, and the proven performance of using treated timber, the use of CCA-treated timber is recommended for construction of the three proposed new groins. This material would blend most effectively with the existing structures, providing the most favorable aesthetic effects of all the materials considered. Using CCA-treated timber would most accurately re-create the historical appearance of the groin field, which is a goal of this project.

Beach Fill Design – Alternative 5. Both alternatives 5a and 5b require the placement of beach fill along the severely eroded eastern 1,300 feet of the park. Unlike the rubble-mound alternative, the relatively short lengths of these groins should minimize any downdrift erosion, so no fill placement is expected to be necessary along the 2,100-foot length of the existing timber groin field. Adequate berm widths currently exist along the length of the existing timber groin field, and due to the proximity of the seagrass beds (near the mlw line throughout most of the western portion of the park) no fill can be placed along this area without impacting seagrass and incurring the additional costs of mitigation. The landward edge of the seagrass beds is located further offshore along the eastern 1,300 feet of the park (see figure 10). The beach fill configuration in this area was designed to minimize impacts to the nearshore seagrass beds while still maintaining adequate beach widths for storm damage protection and recreation.

Fill will be placed in a variable berm-width configuration as shown in figure 15 to approximate the equilibrium shape of the beach, based on the shape of the existing pocket beaches within the existing rubble-mound and timber-pile groin fields. By designing the beach fill to approximate the equilibrium shape of the beach, the volume of sediment transport following construction can be reduced greatly, minimizing erosional losses from the project and decreasing the risk of covering additional areas of the nearshore seagrass beds. The design berm elevation of +6.0 feet mlw corresponds to the originally-authorized project berm elevation along the east side of the island and also corresponds to existing upland elevations along the fill area. Note that this berm configuration would cover the timber groins with approximately 2 feet of sand, providing further protection to the upland parts of these structures. The total volume of material required to construct the proposed beach fill is 8,050 cubic yards. The source of the beach fill would be the adjacent stockpiles of dredged material described previously in this report. The same dune feature described previously for inclusion in alternative 3 would be constructed along the landward edge of the constructed berm. Construction of this 930-foot dune would require an additional 710 cy of fill material.

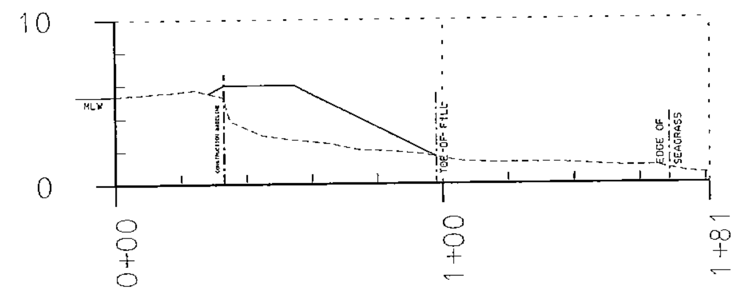
Table 10 shows design data related to construction of the beach fill including volumes required, lengths of fills, and areas of seagrass impacts. The beach fill will be placed in the four 'cells' adjacent to the three new groins along the eastern end of the park. For clarity these cells are numbered consecutively from east to west as shown in figure 15. Beach profiles taken at the eastern, middle, and western end of each of each cell are provided in figure 16.

Table 10
Beach Fill Design Data – Alternative #5

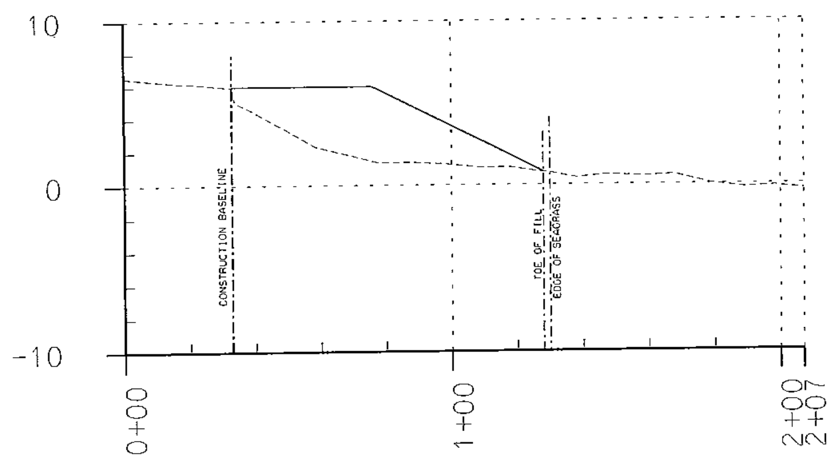
Item	Cell #1	Cell #2	Cell #3	Cell #4	Total
Length of Fill (ft)	350	285	325	330	1,290
Volume of Fill (cy)	2160	1810	3230	850	8,050
Seagrass Impacts (SF)	580	1,605	4,645	610	7,440

CELL 1

EAST



MID



WEST

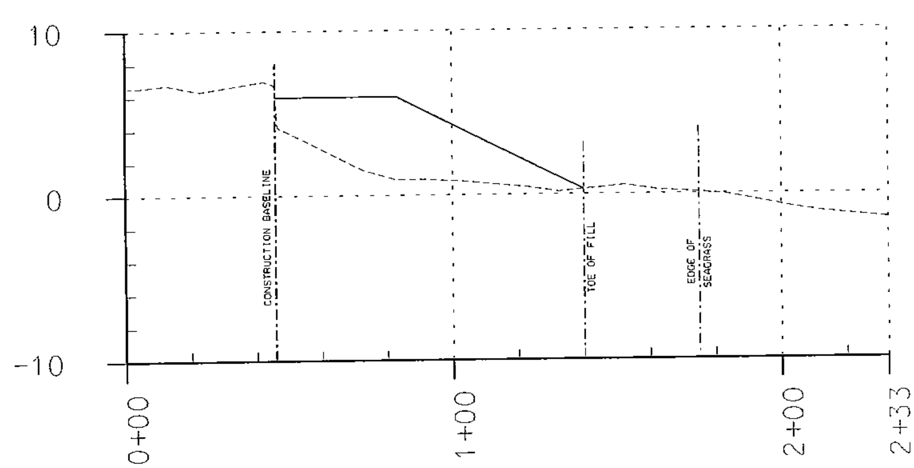


FIGURE 16A

CELL 2

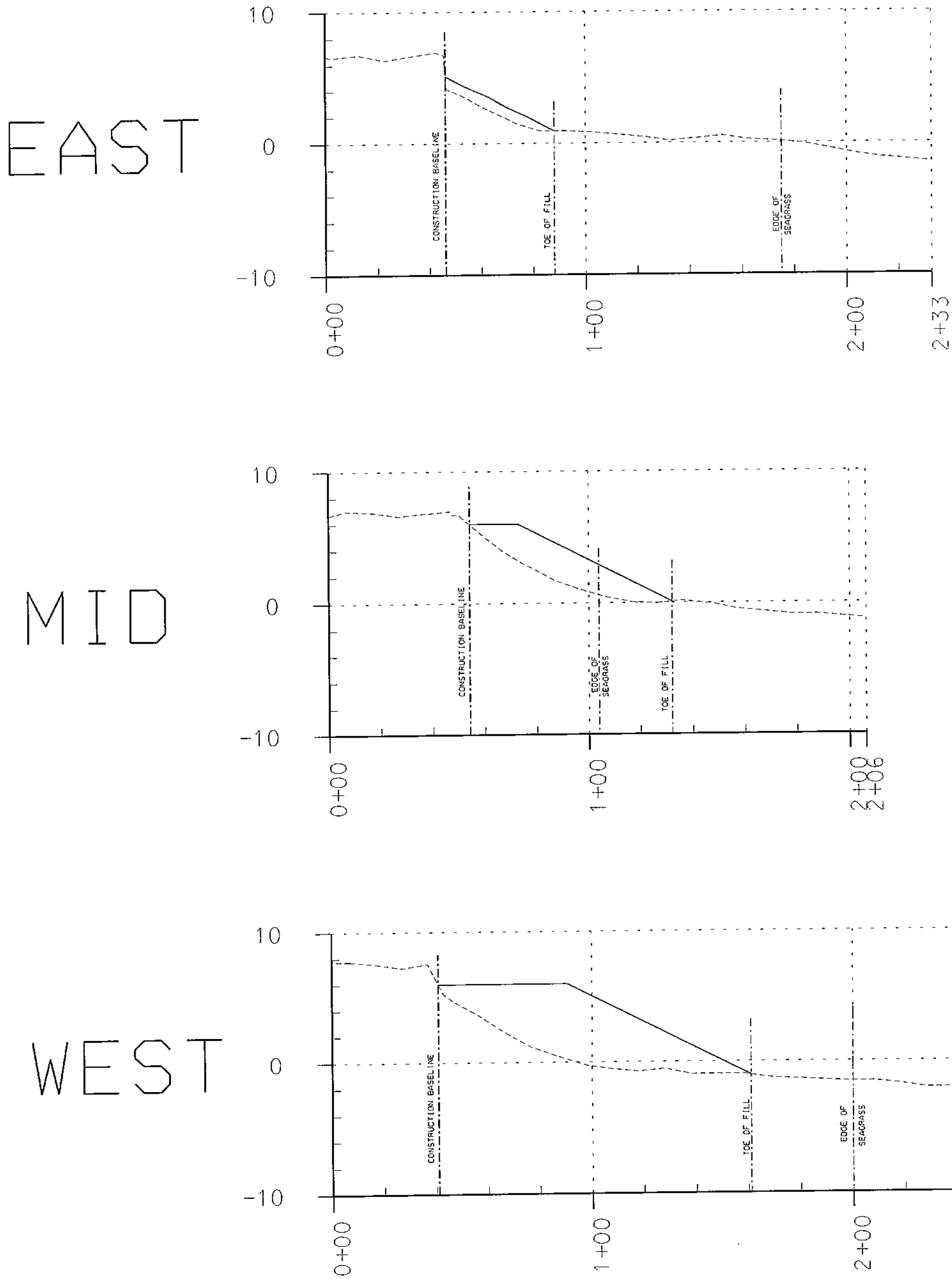
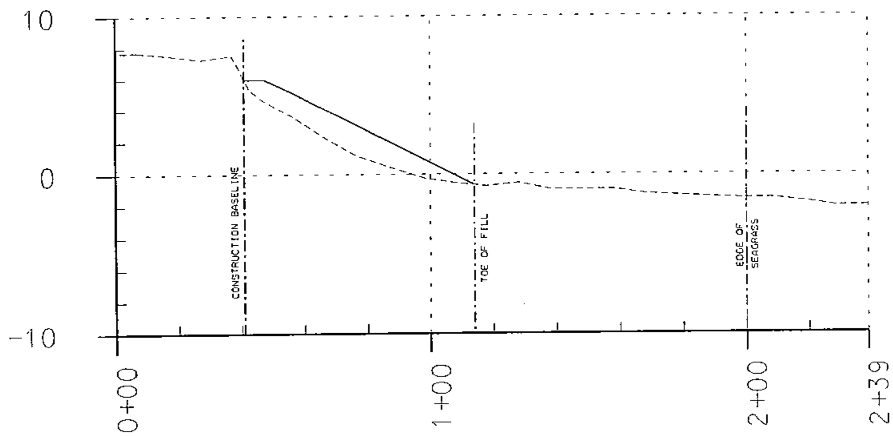


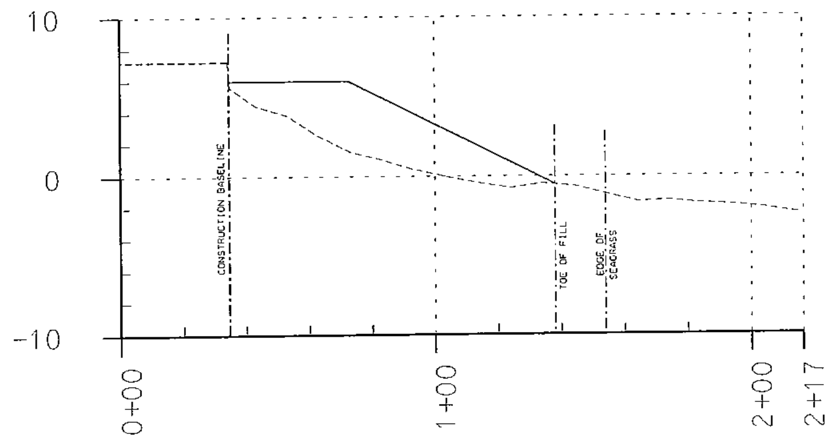
FIGURE 16B

CELL 3

EAST



MID



WEST

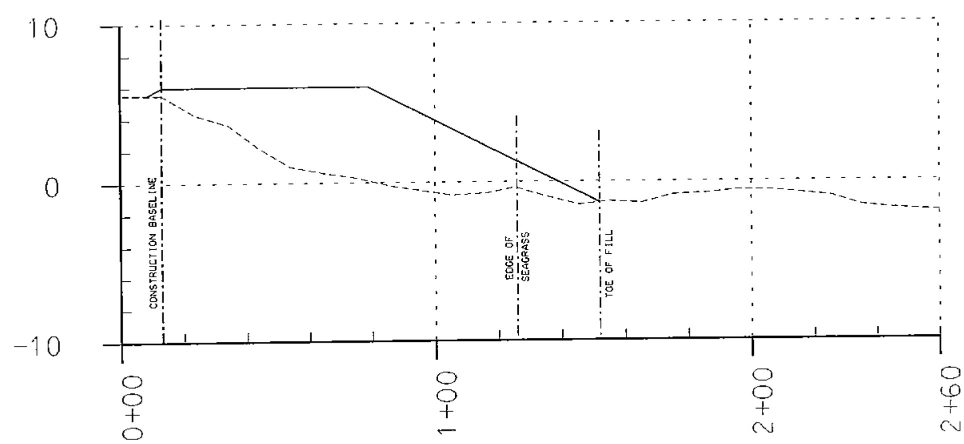


FIGURE 16C

CELL 4

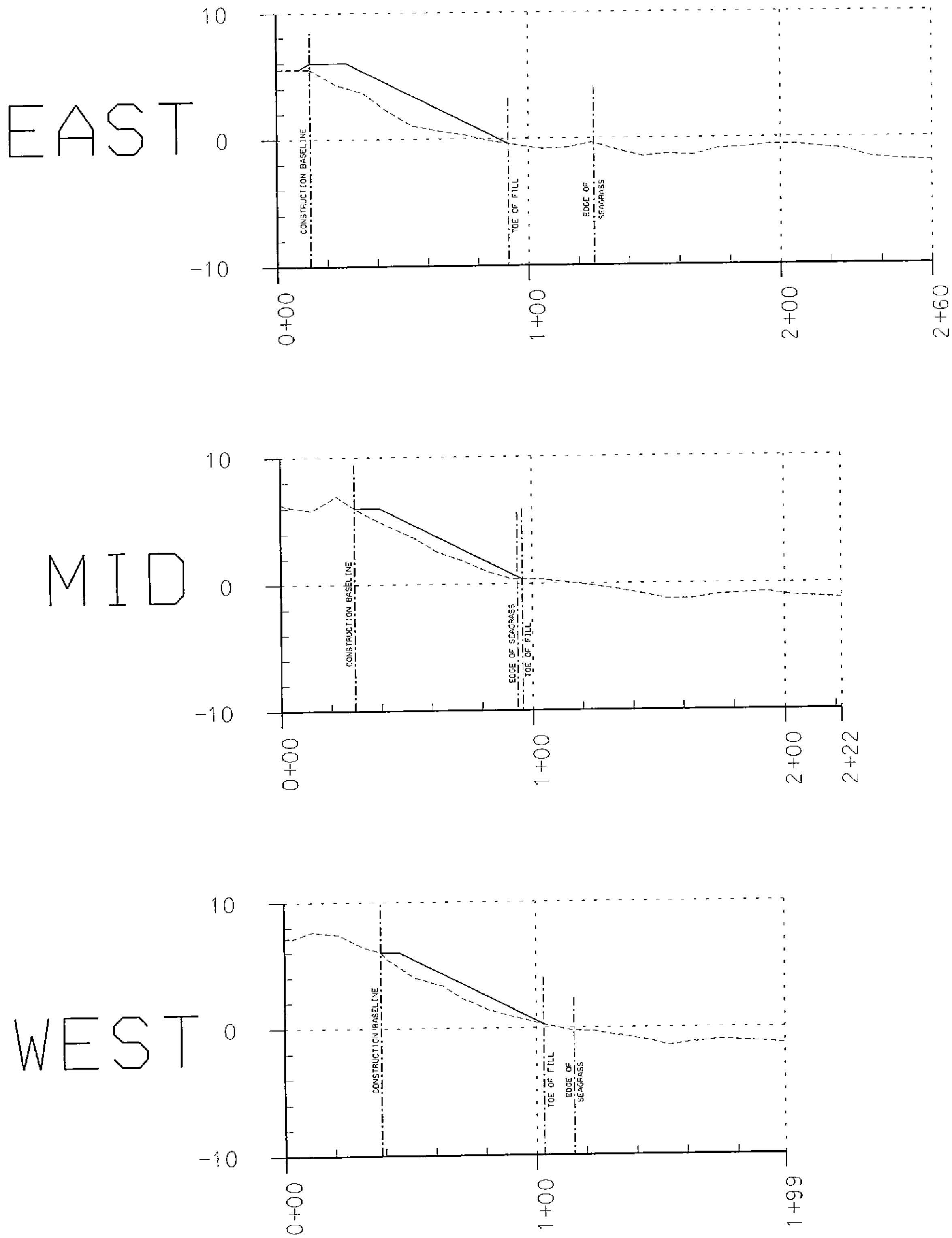


FIGURE 16D

Method of Construction. As shown in figure 3, the timber groins are constructed by first driving 20-foot piles at 10-foot spacings. Three core borings taken along the length of the project shoreline indicate that the minimum depth of bedrock is at 17 feet, which if consistent throughout the project area, will allow adequate depth of penetration for the piles. Piles are driven until either the top elevation of the pile is at +4 feet, mlw or until refusal, in which case the pile is cut off at a top elevation of +4 feet. Horizontal timbers (6"x8") connect across the tops of the piles, with a parallel row of horizontal 6"x8" timbers four feet below the top. Both rows of horizontal supports are placed on the seaward (east) sides of the piles. Vertical 8-ft x 3"x8" planks are driven to a depth of 4 feet below mlw to form the barrier wall of the groin, on the seaward side of the horizontal supports. These vertical planks are nailed to the cross-bracing, and two additional rows of horizontal 6"x8" timbers are placed along the opposite side of the vertical planks and bolted into place. All timbers are CCA-treated and all connecting hardware is galvanized steel.

The design described above will be used for construction of the three new groins, and for rehabilitation of the existing 25 deteriorated groins. As was previously described, two methods of rehabilitating the existing timber groin field will be considered, designated as alternatives 5a and 5b in this report. Both of these alternatives include construction of the three new timber groins along the eastern side of the park. Alternative 5a then involves removing the entire length of each of the 25 existing groins (1030 lf of timber/192 lf of king pile), and rebuilding each of the structures to the lengths shown on highlighted column on the far right side of table 9 under the heading "length of timber groin to be rebuilt" (1190 lf total). As seen in table 9, a total of 13 groins will be shortened by a combination of removing the concrete king piles from 10 structures (192 lf total) and/or removing sections of 6 timber groins that extend into the seagrass beds (100 lf total). The quantities of materials required to construct alternative 5a are shown in table 11a.

In addition to construction of the three new groins, alternative 5b involves repairing only the damaged sections of each of the 25 timber groins. The lengths to be repaired along each groin are listed under the heading "length of timber groin to be repaired", highlighted on the right side of in table 9. For alternative 5b the same 13 groins will be shortened by a combination of removing the concrete king piles from 10 structures (192 lf total) and/or removing sections from 6 timber groins that extend into the seagrass beds (100 lf total). A total of 500 lf of damaged timber groins would removed, and 440 lf would be rebuilt, leaving the (assumed undamaged) upland portions of each groin intact. The quantities of materials required to construct alternative 5b are shown in table 11b.

It is anticipated that complete removal of the buried portions of the damaged timber sections may be difficult. According to the original construction plans the vertical 3"x8" planks extend down to a depth of –4 feet mlw, and piles may extend downward to as much as –16 feet. Due to the deteriorated condition of these timbers, especially the piles, it may not be possible to extract all timbers completely. In order to avoid the complications of driving the new piles on top of the old piles, it is recommended that the fully reconstructed timber groins proposed in alternative 5a be

Table 11a
Quantities of Material Required : Complete Replacement of Timber Groin Field
(Alternative 5a)

Groin	Length,ft	20' Tapered Piles,ea	6"x8" horiz. Bracing,lf	3"x8" vert. Slats,lf	30d Galv. Nails,ea	28"x 3/4" Bolts,ea	17"x 3/4" Bolts,ea	3/4" Washers,ea	3/4" Nuts,ea
A	100	11	400	1200	300	22	20	84	42
B	120	13	480	1440	360	26	24	100	50
C	130	14	520	1560	390	28	26	108	54
1	60	7	240	720	180	14	12	52	26
2	70	8	400	1200	300	16	14	60	30
3	70	8	400	1200	300	16	14	60	30
4	60	7	240	720	180	14	12	52	26
5	60	7	240	720	180	14	12	52	26
6	50	6	200	600	150	12	10	44	22
7	50	6	200	600	150	12	10	44	22
8	60	7	240	720	180	14	12	52	26
9	60	7	240	720	180	14	12	52	26
10	70	8	400	1200	300	16	14	60	30
11	70	8	400	1200	300	16	14	60	30
12	60	7	240	720	180	14	12	52	26
13	50	6	200	600	150	12	10	44	22
14	40	5	160	480	120	10	8	36	18
15	40	5	160	480	120	10	8	36	18
16	30	4	120	360	90	8	6	28	14
17	30	4	120	360	90	8	6	28	14
18	40	5	160	480	120	10	8	36	18
19	30	4	120	360	90	8	6	28	14
20	30	4	120	360	90	8	6	28	14
21	30	4	120	360	90	8	6	28	14
22	30	4	120	360	90	8	6	28	14
23	30	4	120	360	90	8	6	28	14
24	40	5	160	480	120	10	8	36	18
25	30	4	120	360	90	8	6	28	14
TOTAL	1540	182	6640	19920	4980	364	308	1344	672

Table 11b
Quantities of Material Required : Repair of Timber Groin Field
(Alternative 5b)

Groin	Length,ft	20' Tapered Piles,ea	6"x8" horiz. Bracing,lf	3"x8" vert. Slats,lf	30d Galv. Nails,ea	28"x 3/4" Bolts,ea	17"x 3/4" Bolts,ea	3/4" Washers,ea	3/4" Nuts,ea
A	100	11	400	1200	300	22	20	84	42
B	120	13	480	1440	360	26	24	100	50
C	130	14	520	1560	390	28	26	108	54
1	20	3	80	240	60	6	4	20	10
2	50	6	200	600	150	12	10	44	22
3	30	4	120	360	90	8	6	28	14
4	40	5	160	480	120	10	8	36	18
5	10	2	40	120	30	4	2	12	6
6	20	3	80	240	60	6	4	20	10
7	20	3	80	240	60	6	4	20	10
8	30	4	120	360	90	8	6	28	14
9	20	3	80	240	60	6	4	20	10
10	10	2	40	120	30	4	2	12	6
11	30	4	120	360	90	8	6	28	14
12	20	3	80	240	60	6	4	20	10
13	10	2	40	120	30	4	2	12	6
14	10	2	40	120	30	4	2	12	6
15	10	2	40	120	30	4	2	12	6
16	10	2	40	120	30	4	2	12	6
17	10	2	40	120	30	4	2	12	6
18	10	2	40	120	30	4	2	12	6
19	10	2	40	120	30	4	2	12	6
20	10	2	40	120	30	4	2	12	6
21	10	2	40	120	30	4	2	12	6
22	10	2	40	120	30	4	2	12	6
23	10	2	40	120	30	4	2	12	6
24	20	3	80	240	60	6	4	20	10
25	10	2	40	120	30	4	2	12	6
TOTAL	790	107	3160	9480	2370	214	158	744	372

offset about 5 feet on the downdrift (west) side of each existing structure. By constructing on the downdrift side, the contractor would be able to place construction equipment further seaward (on the accreted material east of the original groins), and would generally have less pile-driving to perform since the beach profile is lower on the downdrift side of each of the existing groins. Using this methodology each new groin would be constructed prior to removing the corresponding old groin. For alternative 5b no such offset could be used. All vertical 3"x8" timbers from the damaged sections would have to excavated and completely removed. The piles would be removed to a depth of at least –4 feet mlw, and the new piles would be driven along the original groin alignment, offset slightly landward or seaward to avoid any broken-off buried piles.

Initial Construction Costs. The estimated cost of alternative 5a, consisting of constructing three new timber groins and completely removing and rebuilding the 25 deteriorated timber groins (remove 1222 lf / rebuild 1190 lf), placing 8,050 cubic yards of beach fill and 710 cy for dune construction, and other related activities, is $1,462,900. The estimated cost of alternative 5b, consisting of constructing the same three new timber groins, beach fill, dune, and related activities, and repairing the damaged sections of 21 of the 25 existing timber groins (remove 692 lf / repair 440 lf) is $1,078,300. The initial cost of either timber-groin alternative therefore represents a substantial cost savings compared to the initial cost of rubble-mound groins. This is offset somewhat by the higher maintenance costs of timber groins, however. The maintenance costs associated with each of the two proposed timber-groin rehabilitation alternatives will now be evaluated.

Maintenance Costs. The useful life of the wetted portions of the groins is estimated to be 15 to 20 years based on the use of CCA-treated marine-grade timber. Based on these repair intervals, several repairs and/or replacements can be expected over the project's 50-year economic life for either timber groin rehabilitation alternative. The upland portions of the existing timber groin field appeared to be in good condition during recent site inspections, 50 years after construction of the structures. It is assumed that the upland portions of each of the three new groins and the 25 rehabilitated groins (landward of mhw line) will perform similarly, and will not require replacement throughout this 50-year period. All maintenance activities for alternatives 5a and 5b will be performed along the portions of the timber groins seaward of the mhw line only. In order to determine the future maintenance costs associated with alternatives 5a and 5b, the following set of maintenance schedules will be used.

For alternative 5a, three new timber groins will be constructed, and the entire existing groin field will be removed and rebuilt. Future maintenance of this option will occur at a 20-year repair interval since all materials will be new and in good condition upon completion of initial construction. Following initial construction, replacement of the portions of each groin seaward of the mhw line will therefore be required at years 20 and 40. A total of 95 linear feet along the lengths of the three new groins will lie seaward of the mhw line and will require periodic replacement. A total of 440 linear feet of the rehabilitated existing groin field will lie seaward of the mhw line and will require periodic replacement, bringing the total length of groin replacement per maintenance event to 535 linear feet. The same timber groin design used in the original construction and in the currently proposed repairs (as shown in figure 3) will be used for all future repairs. Maintenance costs will be $ 570,700 for each of the two replacements of 535 lf of timber groins in years 20 and 40. This equates to a present-worth cost of $ 173,801 and $52,930 for repairs in years 20 and 40, respectively, based on a directed discount rate of 6 1/8 percent. The total present worth value of all maintenance costs is therefore $ 226,731, and the total present-worth cost for the timber groin construction and maintenance as proposed in alternative 5a is $ 1,689,630.

The future maintenance costs for alternative 5b are calculated in a similar manner. For alternative 5b, three new timber groins will be constructed, and then 500 lf of damaged timber groin will be removed and 440 linear feet of timber groin will be rebuilt. Future maintenance of this alternative will occur at a 15-year repair interval because higher maintenance can be expected since some of the older materials will be left in place during initial construction. Following initial construction, replacement of the portions of each groin seaward of the mhw line will be required at years 15, 30, and 45. The total length of structure to be repaired during each maintenance event will be the same as the replacement lengths for alternative 5a, i.e. 535 linear feet. The cost of each maintenance event will therefore be the same as alternative 5a, i.e. $570,700 for each maintenance event. The three replacements of 535 lf of timber groins in years 15, 30, and 45 equate to a present-worth costs of $ 233,960, $ 95,912, and $ 39,320, respectively. The total present-worth value of all maintenance is $ 369,192, bringing the total cost of for the timber groin construction and maintenance as presented in alternative 5b to $ 1,447,492.

Summary of Alternatives.

Three proposed alternatives of improvement (alternatives 3, 5a, and 5b) were developed in the preceding sections of this report, including the detailed design of each component of each alternative. The components of each alternative are summarized below :

a) Alternative 3 consists of construction of two new rubble-mound groins (350 linear feet total), and reconstruction of 6 existing timber groins using the rubble-mound design (1,050 linear feet total). A total of eight rubble-mound groins are therefore required, with a total combined linear footage of 1,400 feet. The 25 existing deteriorated timber groins (total 1222 linear feet, including king-pile sections) along the western 2,100 feet of the park's shoreline will be removed and placed in a disposal area within the park. A beach fill consisting of the placement of 30,500 cubic yards of material will be placed along the entire 3,400-foot length of the park following completion of the rubble-mound groins. This fill will be excavated from either of two adjacent borrow areas and then placed mechanically within the fill area. Prior to fill placement, wood debris consisting of downed trees, stumps, rocks, etc will be removed from the fill area and disposed of off-site. A total of 26 concrete king piles will be extracted and stockpiled in a designated area on-site, and the timber panels between the piles will be stockpiled on-site along with the material from the 25 relic timber groins. The areas of seagrass coverage will be 122,150 square feet for beach fill placement, and 37,050 square feet for rubble-mound groin construction. A total area of 159,200 square feet (3.65 acres) of seagrass replanting will therefore be required to mitigate for the effects of this alternative. No maintenance of the groins or beachfill are expected, and maintenance costs are therefore zero. The total cost of alternative #3 is $5,242,700.

b) Alternative 5a consists of construction of three new groins (350 linear feet total) along the eastern 1,300 feet of the park using the timber-pile design instead of the rubble-mound design. The existing 25 timber groins (1,222 linear feet total, including king-pile sections) along the park's shoreline will be completely removed and disposed of in designated disposal areas within the park, and each of these 25 existing timber groins will be rebuilt. A total of 1,190 linear feet of timber groins will be reconstructed, since 13 of the 25 groins will be shortened due to the kingpile removal and to avoid the nearshore seagrass beds. All of the existing debris will be removed from the 1,300-foot beach fill area, and 8,050 cubic yards of beach fill from the adjacent borrow area will be placed mechanically along this reach of eroded shoreline upon completion of the three new timber groins. The 26 king piles (192 linear feet) will be removed and stockpiled in a designated area on-site, and the timber panels between the piles will be disposed of on-site along with the debris from the relic timber groins. The total areas of seagrass coverage will be 7,440 square feet for beach fill placement, 350 square feet for new timber groin construction, and a maximum of 500 square feet for king pile extraction. A total area of 8,290 square feet of seagrass replanting will therefore be required to mitigate for the effects of this alternative. Maintenance of the groins will consist of rebuilding the portion of each of the structures which extends seaward of the mhw line, at 20-year intervals. No maintenance of the beach fill will be required. The total cost of alternative 5a, including projected maintenance costs, is $ 1,689,630.

c) Alternative 5b consists of construction of the same three new timber groins along the eastern 1,300 feet of the park as described above in alternative 5a (350 linear feet total). In this alternative, only the damaged portions of the 25 existing timber groins will be removed (total 692 linear feet, including king pile sections) and reconstructed (440 linear feet total). All materials removed from the damaged groins will be disposed of in designated disposal areas on-site. As in alternative 5a, 13 of the 25 groins will be shortened from their original lengths due to king pile removal and to avoid the nearshore seagrass beds. All of the existing debris will be removed from the 1,300-foot beach fill area, and 8,050 cubic yards of beach fill from the adjacent borrow area will be placed mechanically along this reach of eroded shoreline. The 26 king piles (192 linear feet) will be removed and stockpiled on-site, and the timber panels between the piles will be disposed of on-site along with the timbers removed from the damaged relic groins. The total areas of seagrass coverage will be 7,440 square feet for beach fill placement, 350 square feet for new timber groin construction, and a maximum of 500 square feet for king pile extraction. A total area of 8,290 square feet of seagrass replanting will therefore be required to mitigate for the effects of this alternative. Maintenance of the groins will consist of rebuilding the portion of each of the structures which extends seaward of the mhw line, at 15-year intervals. No maintenance of the beach fill will be required. The total cost of alternative 5b, including projected maintenance costs, is $ 1,447,492.

Selection of Recommended Plan.

Although the maintenance costs are higher with timber groins, replacement costs are low enough to justify their use based on cost considerations alone. However, the use of timber-pile groins offers other advantages as well. The 'footprint' of construction is much smaller for timber groins since the width of the construction zone is a few feet, compared to 44+ feet for the rubble-mound structures. The timber groin design stabilizes the beach by using a greater number of structures spaced more closely than the comparable rubble-mound design, but since the timber groins are much shorter the total length of structure is about the same for each design (1540 lf for timber vs 1400 lf for rubble). The cost per unit length of structure is significantly less for timber groins however, and the resulting total project costs are much lower for the timber groin alternatives in spite of their higher maintenance requirements. The shorter groin lengths significantly reduce adverse environmental impacts due to seagrass coverage from the structures and the beach fill (8,290 sq ft for timber groin design vs 159,200 sq ft for rubble design), and the corresponding mitigation requirements and costs will be much less using the timber groin design. The timber groin design will also blend in aesthetically and restore the appearance of the historical groin field which was originally constructed along Old County Park. The use of timber groins is therefore recommended over rubble-mound structures. Due to uncertainties as to the condition of the buried upland portions of the existing timber groins, complete replacement of the structures is recommended as described in alternative 5a. A plan view of the recommended plan, alternative 5a, is shown in figure 15. Plates 1 through 25 at the end of this text provide profile views of the recommended improvements to each of the 25 timber groins, in accordance with the data presented in table 9.

Hydrodynamic Modeling of Recommended Alternative.

General. Hydrodynamic modeling of Bear Cut was performed in order to simulate the effects of the proposed plan of improvement on current velocities throughout the project area. This modeling was performed using RMA-2 v4.3, which is a two-dimensional depth-averaged finite-element hydrodynamic numerical model. RMA-2 computes water surface elevations and horizontal velocity components for subcritical, free-surface flow in two dimensional flow fields. As part of the ongoing Biscayne Bay Feasibility Study, the U.S. Army Engineer Research and Development Center, Coastal and Hydraulics Laboratory (CHL) was tasked with developing a physics based numerical model of Biscayne Bay. The goals of the CHL effort were to develop a two-dimensional finite element hydrodynamic and salinity transport model. A draft technical report titled "Development of a Two-Dimensional Numerical Model of Hydrodynamics and Salinity for Biscayne Bay, FL" [reference (m)] documents the development and verification of the model. The draft report is currently under review. The domain of the Biscayne Bay model includes the Virginia Key study area. The portion of the Biscayne Bay model in the vicinity of Bear Cut was adopted and refined for use in the Virginia Key study. This resulted in considerable savings of time and cost associated with model development for the Virginia Key study.

Model Geometry. The model geometry file from the Biscayne Bay model was obtained from CHL and a portion of the mesh appropriate for the Virginia Key study was cropped out. The resulting mesh was then refined in the area of interest along the Virginia Key shoreline. The original mesh size of approximately 500,000 square feet per element was refined to approximately 450 square feet per element in the area of interest along the Old County Park shoreline. In addition, new survey data procured for the Virginia Key study was incorporated to further improve model bathymetry. The Virginia Key mesh contains 19326 nodes and 6824 elements and is shown in figure 17. A more detailed view of the mesh in the vicinity of the project area is shown in figure 18.

Boundary Conditions. Boundary conditions for the Biscayne Bay model include transient head boundaries on the ocean side to simulate tides, as well as volumetric inflows at locations corresponding to major canals to simulate freshwater inflows. The Biscayne Bay model control file runs the model at 30-minute time steps for a period of 10 months spanning the time from September 1997 through June 1998. Tidal action dominates the hydrodynamics in Bear Cut, therefore the bayside freshwater inflows can be ignored. Accordingly, transient water surface elevations were extracted from the Biscayne Bay model solution file at nodes which form the pen boundaries on the bay and ocean sides of Bear Cut in the Virginia Key model. Since the full 10 months of runtime were not needed to adequately simulate tidal action for this study, 2 weeks of data were extracted corresponding to a spring tide in September 1997, thereby simulating high flow conditions in Bear Cut. The resulting runtime for the Virginia Key model is 720 30-minute time-steps.

Existing Condition Model Geometry. The existing condition shoreline was delineated from a high-resolution georeferenced color aerial photograph. The existing groin field was included in the model geometry based on interpretation of the photograph and GPS data points provided by Miami-Dade Department of Environmental Resource Management. The existing conditions for the model simulations are shown in figures 17 and 18.

With-Project Model Geometry. The with-project model geometry includes the modified shoreline position based on the addition of beachfill along the eastern 1,300 feet of the park, addition of the three new groins along the same reach, and the removal of the seaward portions of several existing timber groins as described previously in this report, in order to remove these structures from the proximity of the seagrass beds. Since the proposed new groins, rehabilitated groins, and beachfill configuration are all identical for alternatives 5a and 5b, the with-project conditions for both alternatives are shown in figure 19.

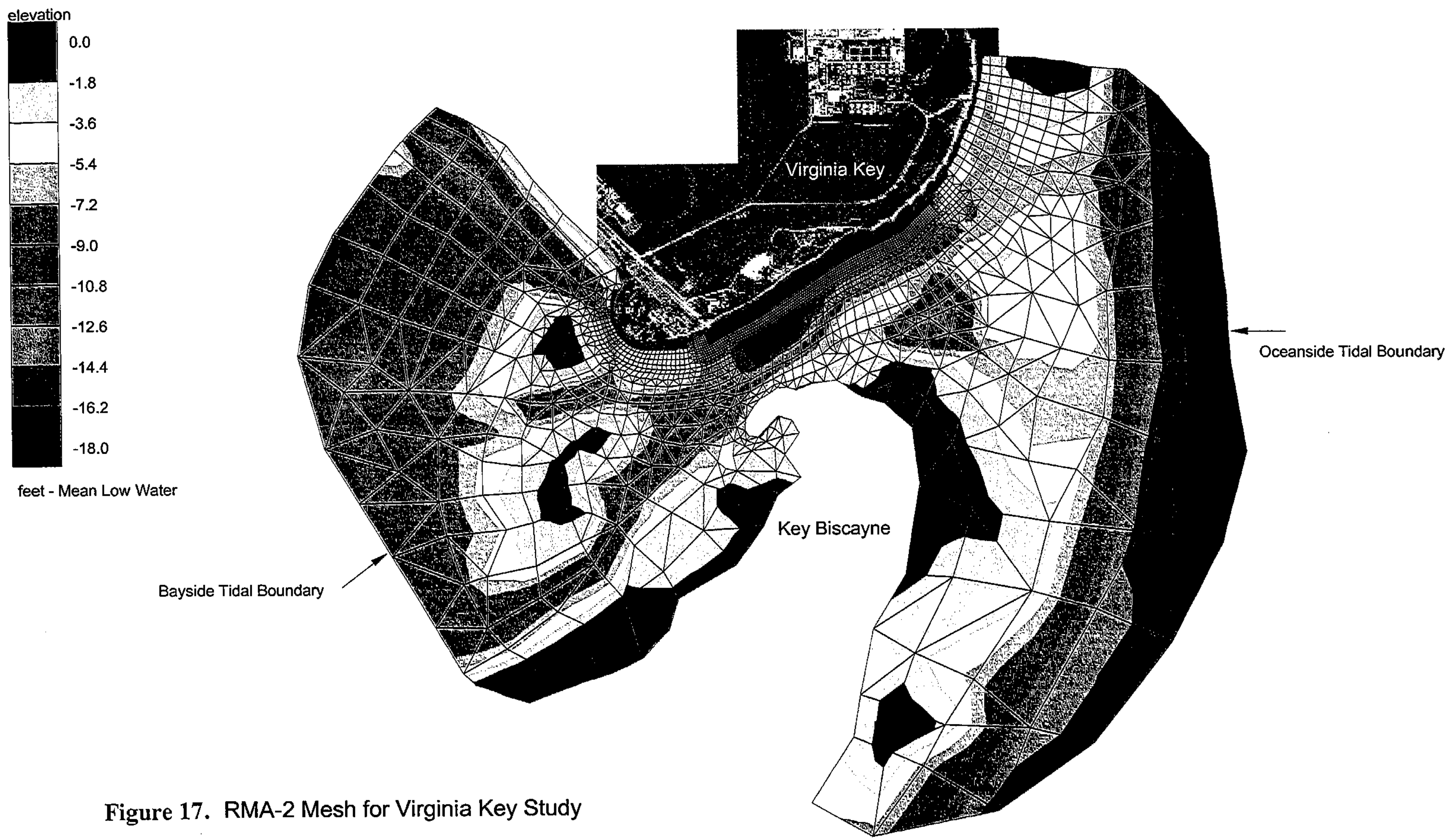


Figure 17. RMA-2 Mesh for Virginia Key Study

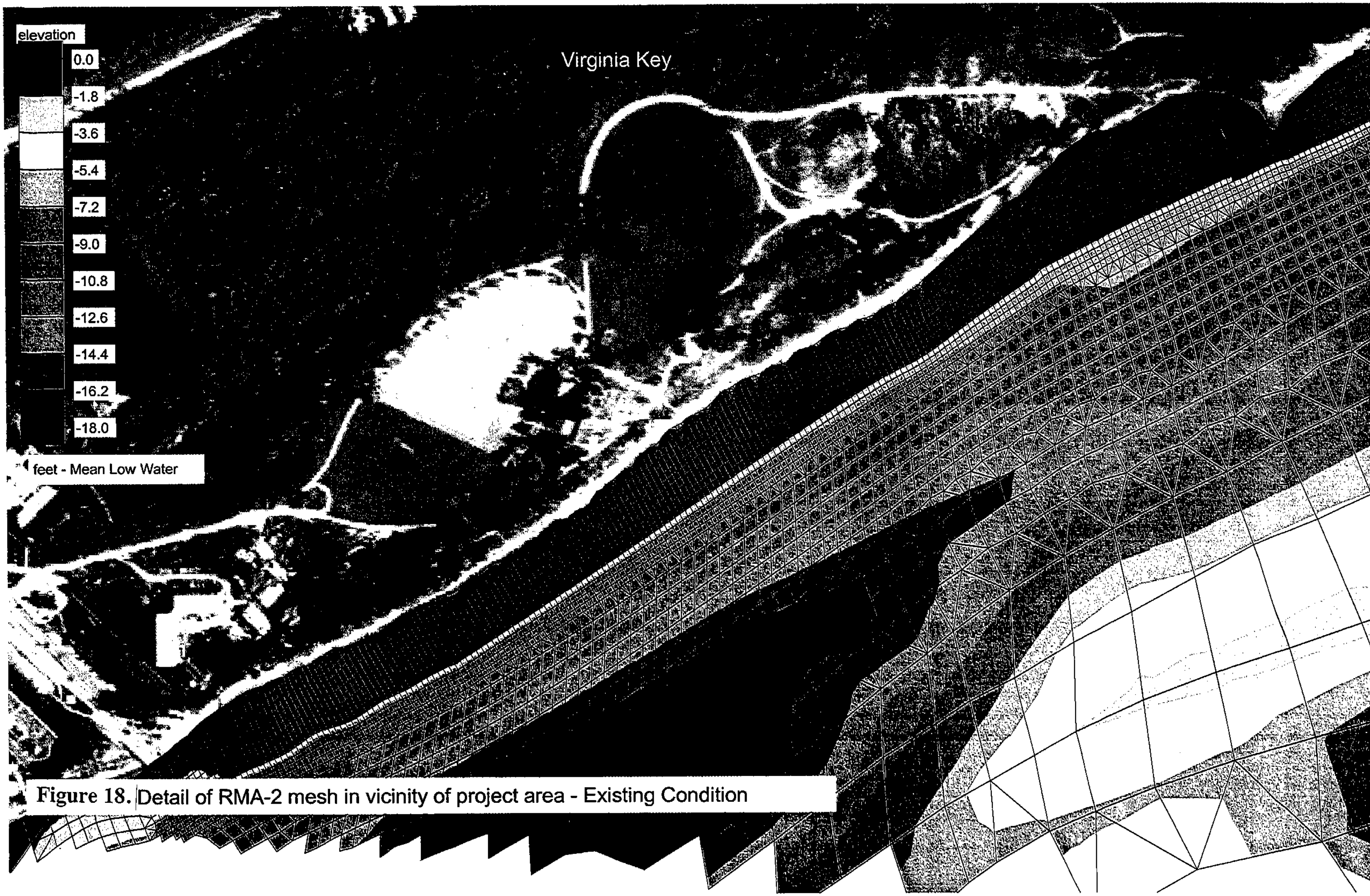


Figure 18. Detail of RMA-2 mesh in vicinity of project area - Existing Condition

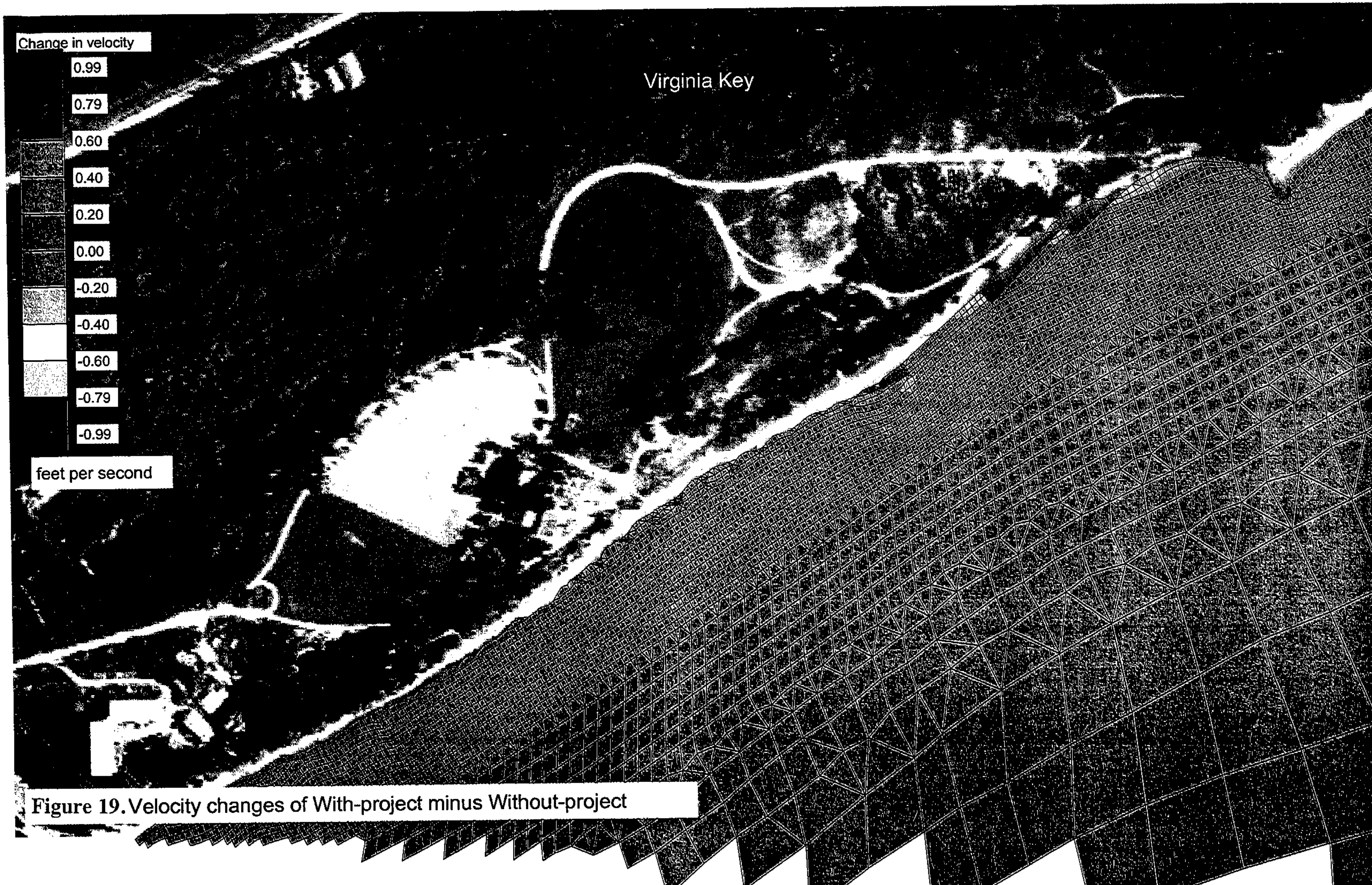


Figure 19. Velocity changes of With-project minus Without-project

Model Output. Model output was post-processed to show changes in flow velocities between the two configurations. Velocity vectors at each node in the mesh from the with-project solution file were subtracted from the velocity vectors at each corresponding node in the existing condition (without project) solution file. This produced a scalar data set of the differences in velocity magnitudes between the with- and without- project conditions, at each node in the mesh for all time-steps. The time step that produced the largest differences was selected and a contour map of these differences is shown in figure 19.

Model Results. Velocities within the model domain for both configurations range from 0.0 feet per second during slack tide to a maximum of 2.5 fps during the spring tide on the flood cycle. Maximum velocities are found in the deep part of Bear Cut channel approximately 750 feet offshore of the project area. In the shallow zone within 150 feet of the shoreline near the project features, velocities for the existing condition range from near zero to 0.8 fps. The changes in velocities predicted by the model as a result of the proposed shoreline modifications are shown in figure 19. These velocity changes range from approximately –1.0 fps to +1.0 fps and are concentrated in limited areas adjacent to proposed project features. As seen in figure 19, the velocities throughout the remainder to the project area remain unchanged as a result of the proposed improvements.

Conclusions. The comparative numerical modeling shows that there will be virtually no changes in current velocities along the park's shoreline, except for some minor velocity changes in the immediate vicinity of some of the proposed project features. These velocity changes are less than 1.0 fps in magnitude, even under the most severe tidal current conditions. Tidal current velocity changes throughout the majority of the lunar tidal cycle should be even lower than the values shown in figure 19.

SUMMARY OF SELECTED PLAN

Alternative 5a is chosen as the selected plan. This alternative will provide the most effective stabilization of the Old County Park shoreline with the least environmental impacts, and will blend with the aesthetics of the area and restore the historical appearance of the park's shoreline better and at a lower cost than alternative 3. Numerical modeling has demonstrated that construction of this alternative will provide no significant changes to the current velocities and patterns along the project shoreline. A plan view of alternative 5a is shown in figure 15, and a description of the selected plan of improvement follows:

The selected plan consists of three main elements, including the construction of three new timber groins along the eastern 1,300 feet of the park, the complete removal and reconstruction of the existing 25 relic timber groins, and placement of a beach fill and dune along the eroded eastern portion of the park. The three new timber groins will total 350 linear feet in length and will be similar in design to the historic timber groins along the park. The existing groin field within the park consists of 25 structures totaling 1,222 linear feet, comprised of 1,030 linear feet of timber groin and 192 feet of concrete king pile groin. These structures will be completely removed and stockpiled on-site, and each of these 25 groins will be partially or totally rebuilt.

Some modifications to the existing timber groin field are recommended. All concrete king piles and connecting timbers between these piles will be removed, since these structures have deteriorated to the point where they are no longer effective, and since most of the king piles extend into the seagrass beds. After removal, the concrete piles and timbers will be disposed of in separate disposal areas on-site for later use by the local sponsor. The timber portions of six groins will be shortened an additional 100 lf total, in order to remove these portions of the structures from the seagrass beds. Four groins will be lengthened by 10 feet each, into the region formerly occupied by the concrete king piles, in order to increase the effectiveness of these structures. Finally, twelve groins will be extended further landward by a total of 220 lf in order to better anchor these structures into the upland area to prevent flanking. A total of 1,190 linear feet of timber groins will therefore be rebuilt. Profile views of the improvements to be made at each of the 25 existing timber groins are shown in plates 1 through 25 at the end of this text.

Prior to construction of the beach fill all of the existing debris (including downed trees, stumps, logs, rocks, trash) will be removed from the 1,300-foot beach fill area and disposed of off-site. The beach fill will consist of the placement of 8,050 cubic yards of beach fill from the adjacent borrow area(s). Fill will be placed mechanically along this reach of eroded shoreline in a variable berm-width configuration as shown in figure 15. Following completion of the beach fill, a 2-foot high dune feature will be constructed along the landward edge of the berm along a 930-foot reach of shoreline at the east end of the park. Construction of the dune will require the placement of 710 cy of additional fill, which will be removed from the same borrow site(s) as the beach fill material.

The total area of seagrass coverage will be 7,440 square feet for beach fill placement, 350 square feet for new timber groin construction, and a maximum of 500 square feet for king pile extraction. A total area of 8,290 square feet of seagrass replanting will therefore be required to mitigate for the effects of this alternative.

The cost for constructing all of the elements of the selected plan as described above is $1,462,900. The present worth of all maintenance costs throughout the life of the project is $226,730. The total estimated project cost including maintenance is $1,689,630.

CONCLUSIONS

Based on an analysis of the costs of alternatives 3, 5a, and 5b presented in this report, it is apparent that the construction of the timber groin field is much more economical than construction of the rubble-mound groin field, in spite of the higher maintenance costs associated with the timber structures. The environmental impacts are considerably lower with the timber structures since the surface area covered by timber groins is almost negligible when compared to the area of coverage of the rubble-mound design. The timber groin design also blends well with the existing historical groins in the park. The use of timber structures is therefore recommended over the use of the rubble-mound design. Since the condition of the upland portions of many of the 25 existing timber groins will remain unknown as long as they remain buried, it should be assumed that these portions of the structures are deteriorated to the point of requiring replacement. Under these conditions Alternative 5a is the recommended plan of improvement.

RECOMMENDATIONS

The recommended plan of improvement is alternative 5a as described in this report. Under the provisions of this alternative, the following actions are recommended for the restoration of the shoreline at Virginia Key's Old County Park :

a) Construction of three new timber-pile groins along the 1,300-foot reach of eroded shoreline at the eastern end of the park. A total of 350 linear feet of new groins will be constructed, and the groins will be of a design similar to the existing historic structures along the western end of the park.

b) Construction of a beach fill along the eroded 1,300-foot eastern end of the park following completion of the three new timber groins described above. This beach fill will require the placement of 8,050 cubic yards of material. The source of this material will be either of two stockpiles of dredged material located adjacent to the project area. Various debris along the existing shoreline will be removed and disposed of off-site prior to fill placement, including numerous logs, rocks, downed trees, stumps, etc.

c) Following completion of the beach fill, a 2-foot high dune feature will be constructed along the landward edge of the berm along a 930-foot reach of shoreline at the east end of the park. Construction of the dune will require the placement of 710 cy of fill, which will be removed from the same borrow site(s) as the beach fill.

d) Removal of 26 concrete king piles and horizontal timber panels (192 lf of structure) along the central portion of the existing timber groin field. The concrete piles and the timber panels will be stockpiled in separate areas on-site for future use by the local sponsor.

e) Removal of the entire length of each of the 25 timber groins (1,030 lf total, after removal of the 192 lf of concrete kingpiles) and reconstruction of each of the 25 timber groins (1,190 lf total). Note that six of the 25 timber groins will be shortened (100 lf total), four will be lengthened (40 lf total), and twelve will be extended further landward (220 lf total).

f) Maintenance would consist of the periodic rebuilding of those portions of the timber groins which would be exposed to wetting and drying, due to expected damage from marine organisms. The completely reconstructed groin field presented in alternative 5a would require the replacement of 535 linear feet of structure every 20 years. No maintenance of the beach fill is anticipated. The estimated cost of each maintenance event is $ 570,700.

g) The cost for constructing the complete rehabilitation of the Old County Park shoreline as described above, assuming complete reconstruction of the timber groin field (alternative 5a) is $1,462,900. The present worth of all maintenance costs throughout the life of the project is $226,730. The total estimated project cost including maintenance is therefore $1,689,630.

REFERENCES

a) Virginia Key and Key Biscayne, Florida, Beach Erosion Control, General and Detail Design Memorandum, February, 1968.

b) Dade County, Florida, Beach Erosion Control and Hurricane Protection Report, U.S. Army Engineer District, Jacksonville, FL. June 1965.

c) Dade County Beaches, Florida, Beach Erosion Control and Hurricane Surge Protection Project, General Design Memorandum, U.S. Army Corps of Engineers, Jacksonville District, September 1975.

d) U.S. Army Corps of Engineers, Shore Protection Manual 1977 - 84.

e) Flood Insurance Study, Dade County, Florida, and Incorporated Areas, FEMA, November 1987.

f) NOAA, Effects of Hurricane Andrew on Water Levels in Coastal Florida and Louisiana, Data Report, Technical Memorandum NOS OES 004, December 1992.

g) Hindcast Wave Information for the U.S. Atlantic Coast, WIS Report 30, U.S. Army Corps of Engineers Waterways Experiment Station, March 1993.

h) Assessment of Wave Conditions During Hurricane Andrew (1992) at Miami Beach, Florida, Coastal Engineering Research Center, April 1993.

i) Coast of Florida Erosion and Storm Effects Study, Region III, Feasibility Report, U.S. Army Corps of Engineers, October 1996.

j) "Dade County Regional Sediment Budget", Coastal Systems International, Inc, Coral Gables, Florida, January 1997.

k) "Dade County Alternate Sand Source Investigation", Coastal Planning & Engineering, Boca Raton, Florida, September 1997.

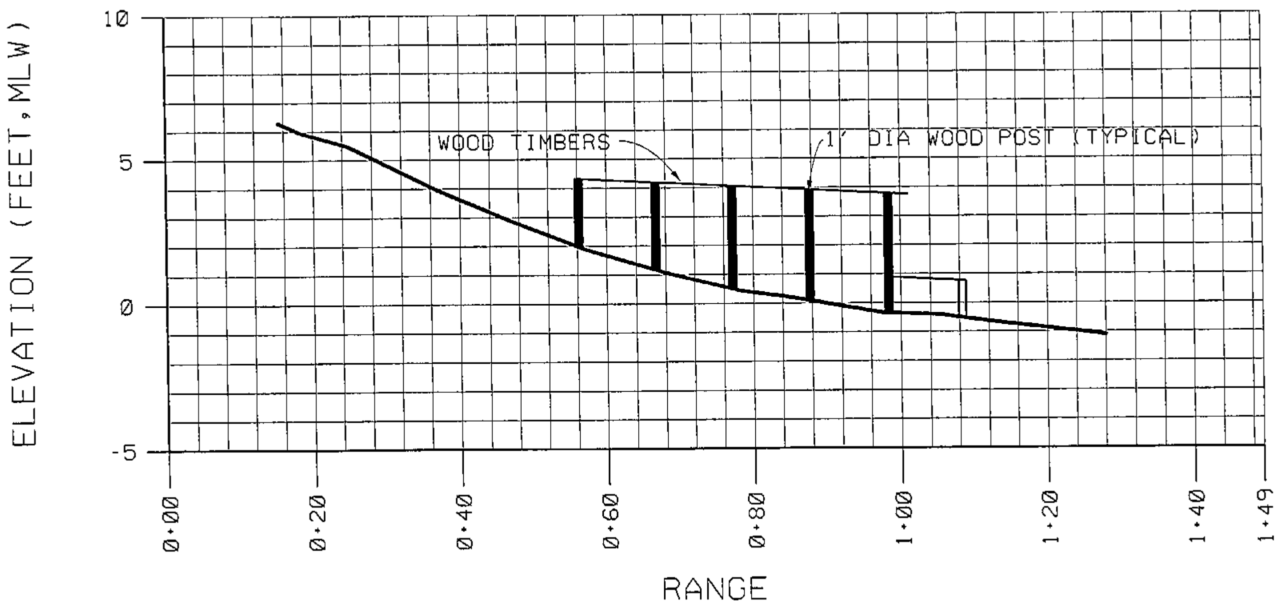
l) "Virginia Key Beach Park Charrette", University of Miami, Rosenstiel School of Marine and Atmospheric Science, January 2000.

m) "Development of a Two-Dimensional Numerical Model of Hydrodynamics and Salinity for Biscayne Bay, FL", Engineering Research Development Center, November 2000.

n) NOAA, Tide Tables 2001, East Coast of North and South America, 2001.

o) NOAA, Tidal Current Tables 2001, Atlantic Coast of North America, 2001.

GR N 1



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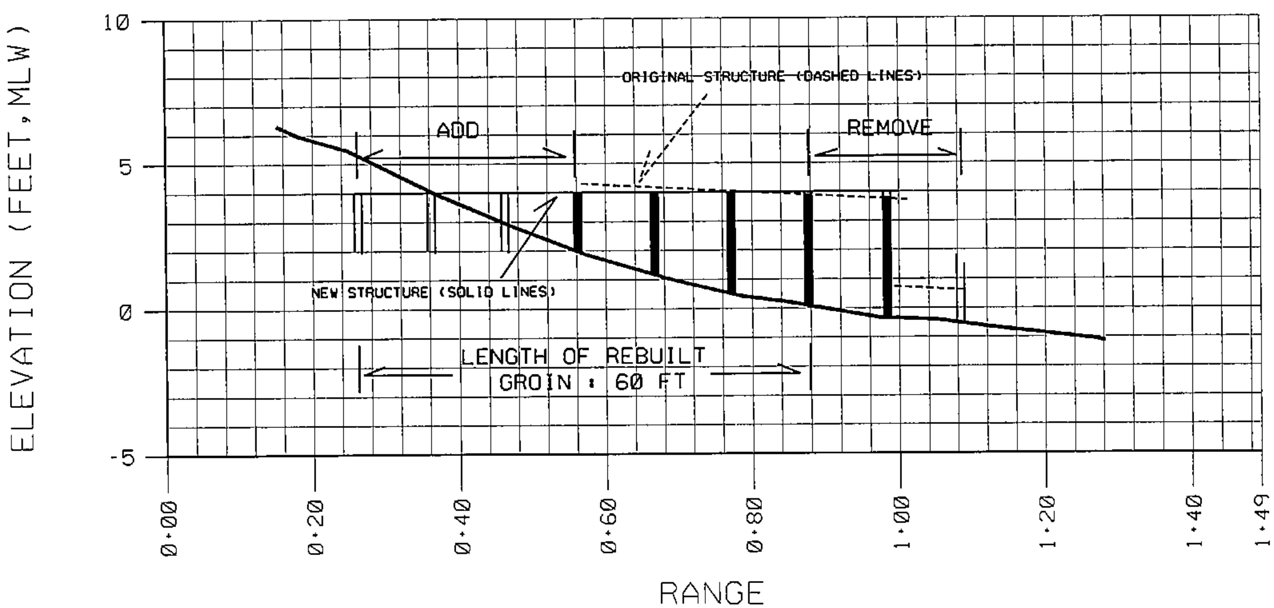
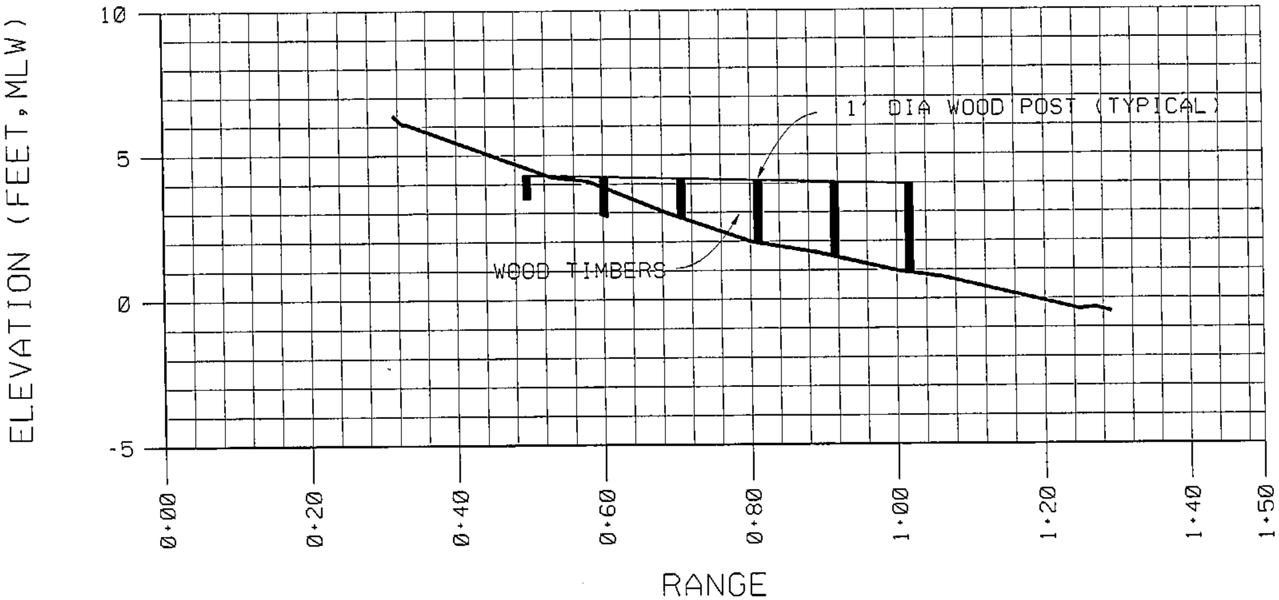


RECOMMENDED IMPROVEMENT

PLATE 1

GROIN 2



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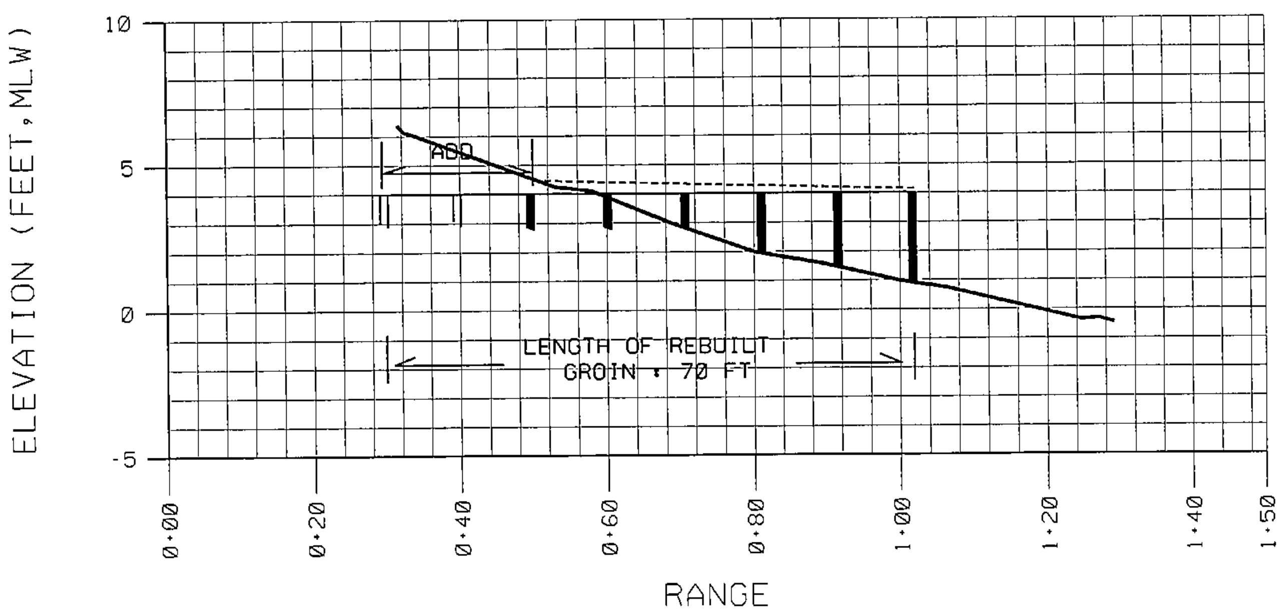
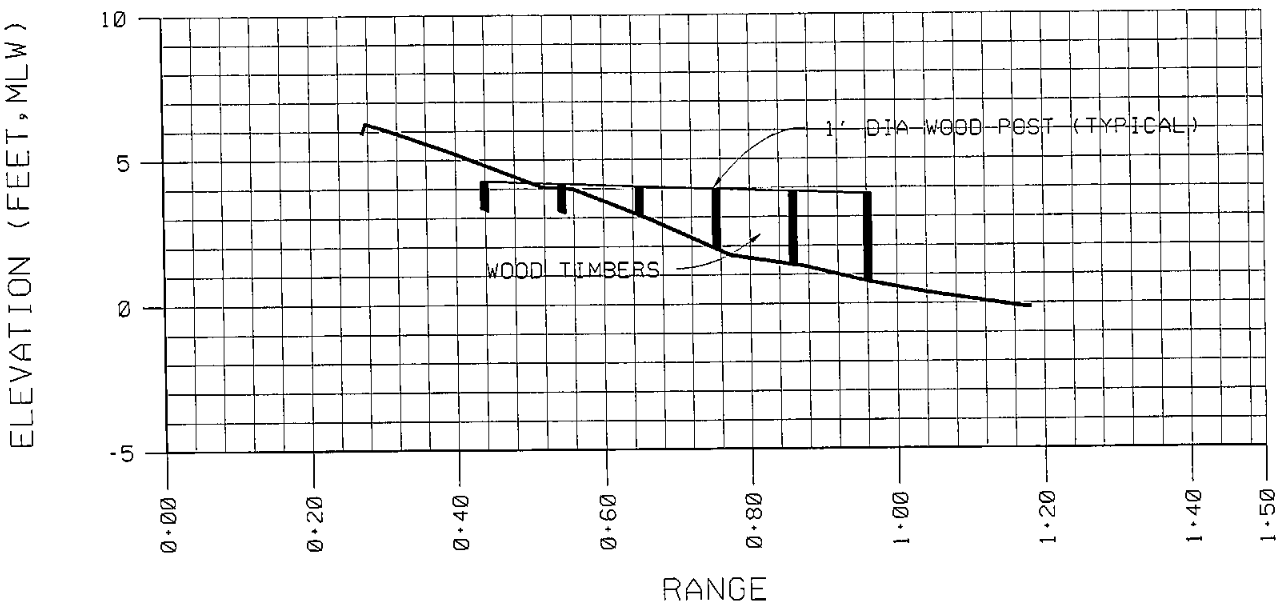


RECOMMENDED IMPROVEMENT

PLATE 2

GROIN 3



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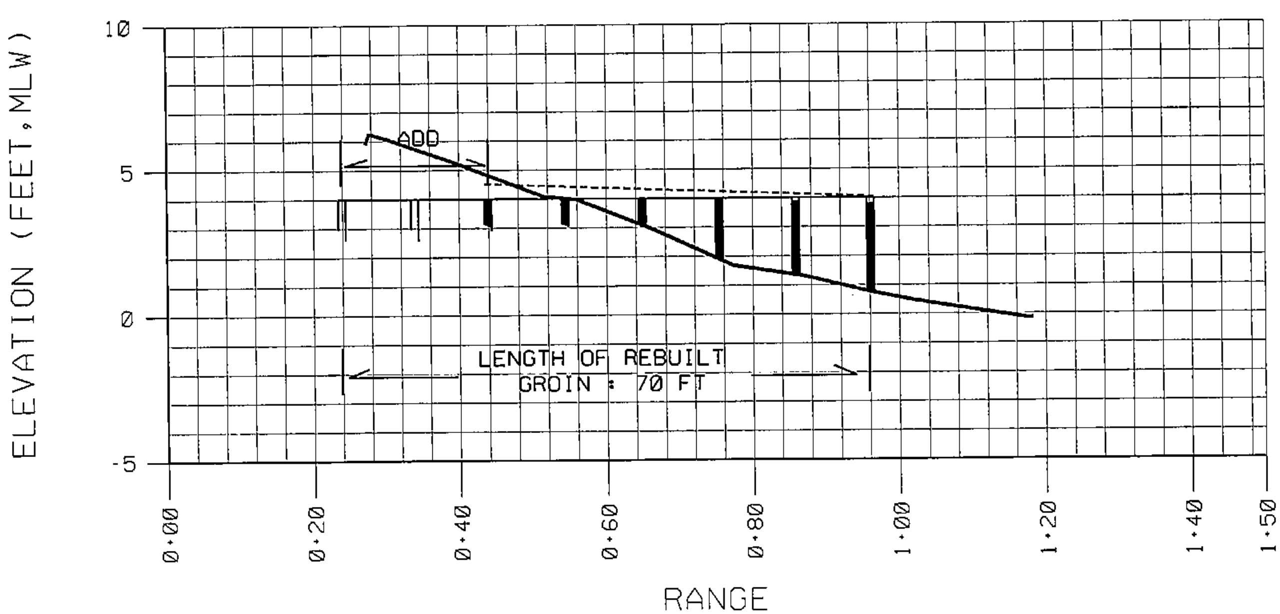
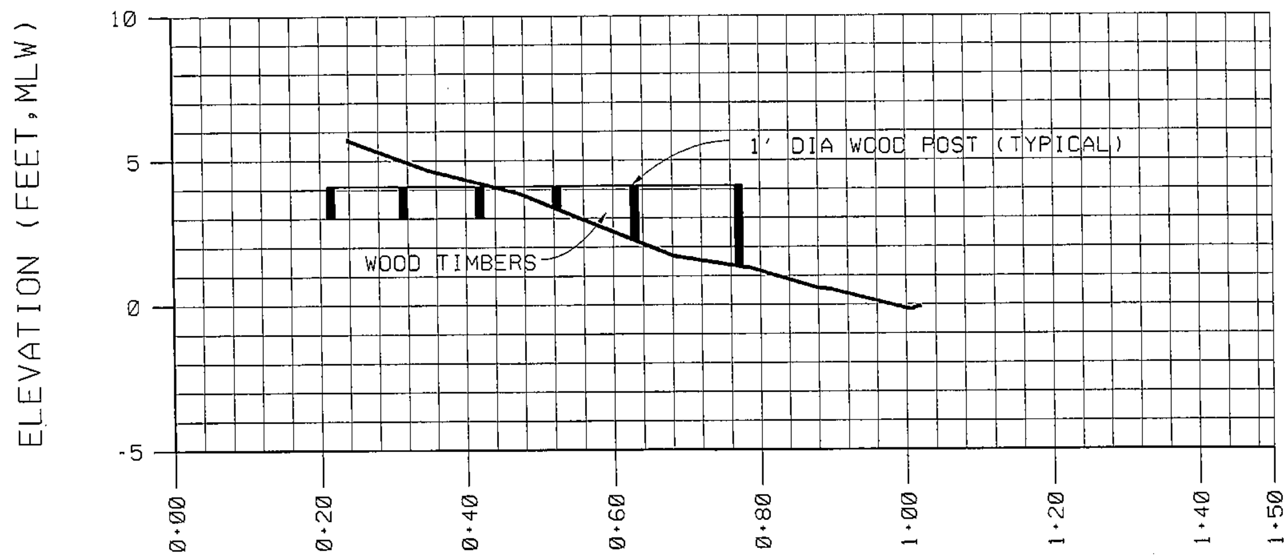


RECOMMENDED IMPROVEMENT

PLATE 3

GROIN 4



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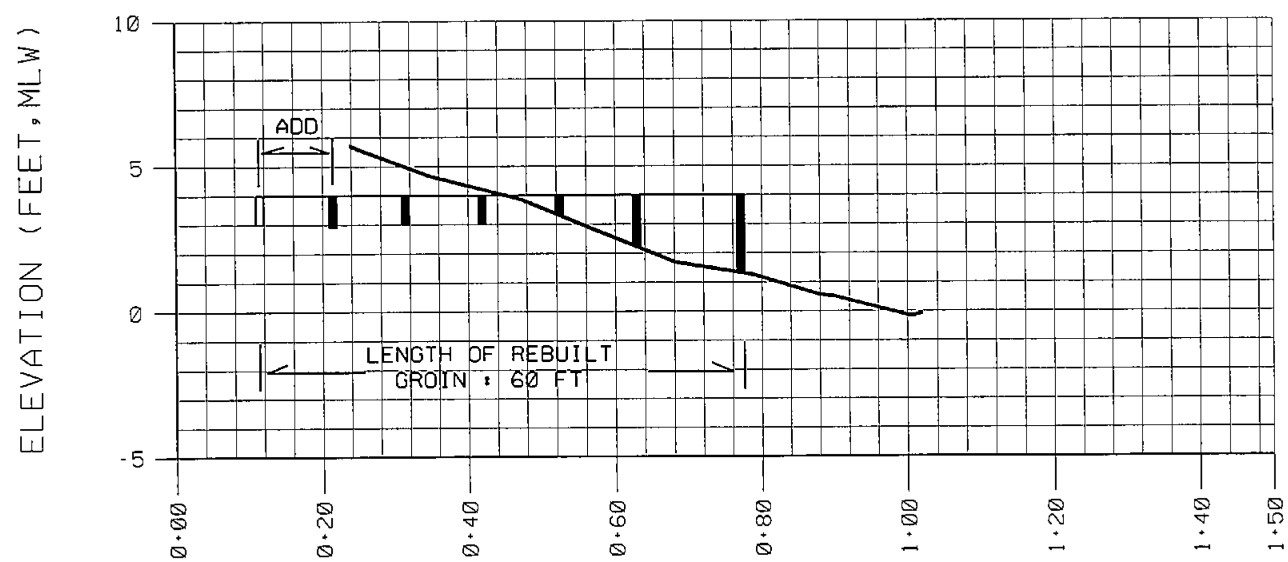
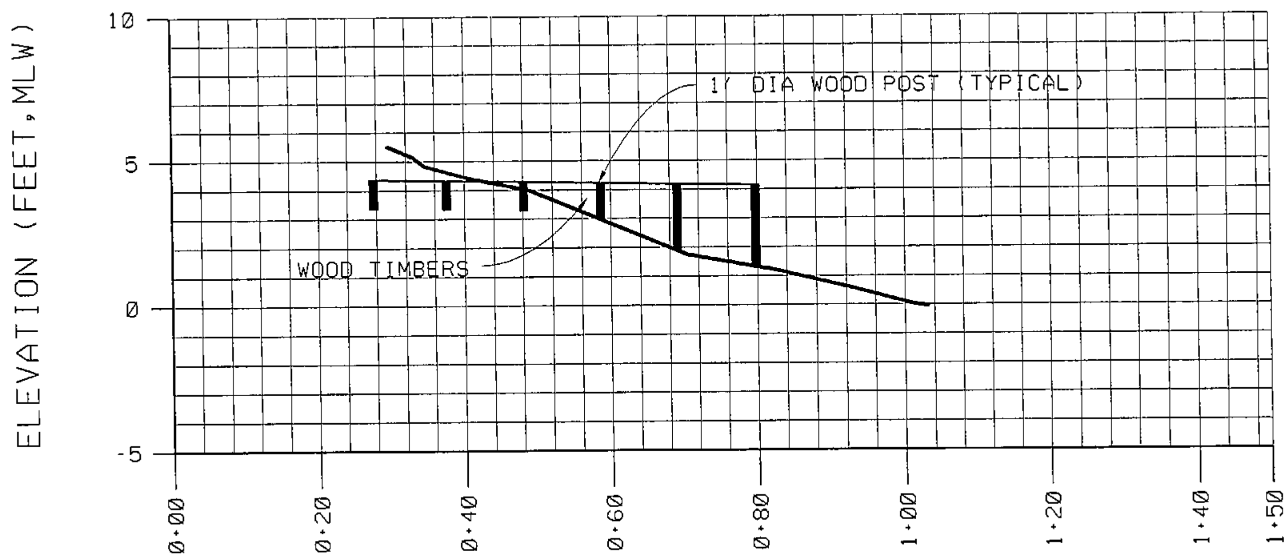


RECOMMENDED IMPROVEMENT

PLATE 4

GR(_N 5



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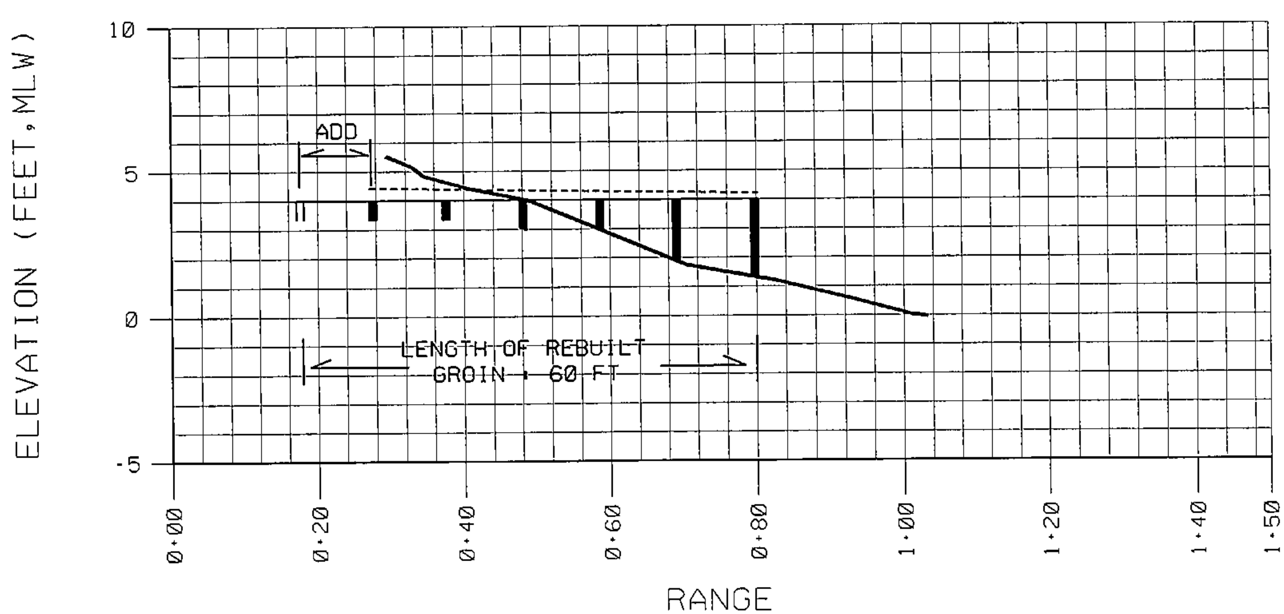
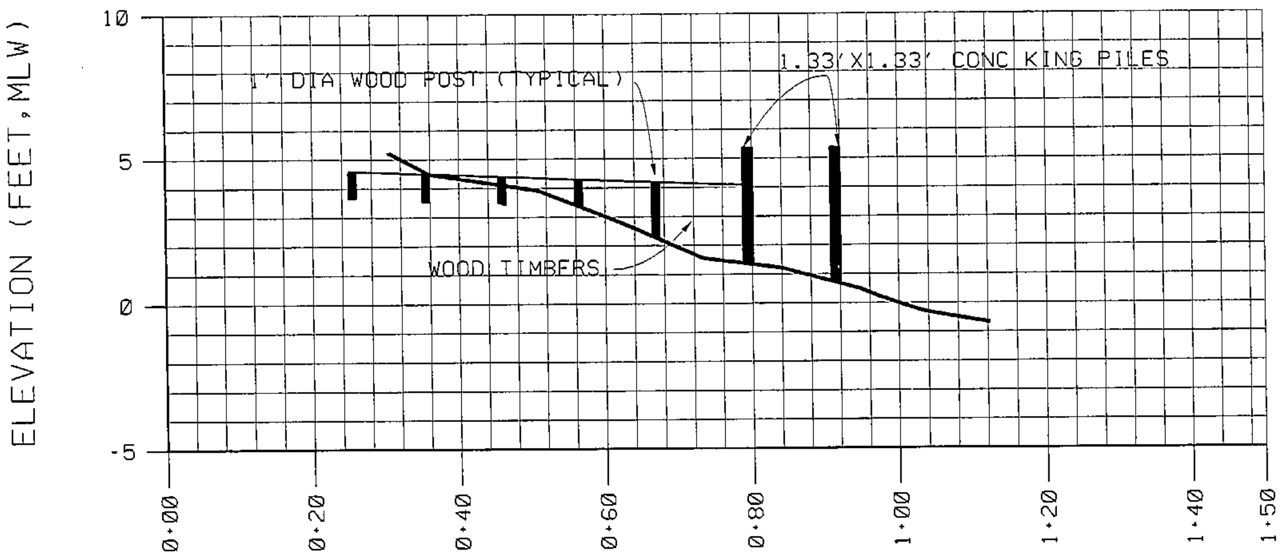


RECOMMENDED IMPROVEMENT

PLATE 5

GROIN 6



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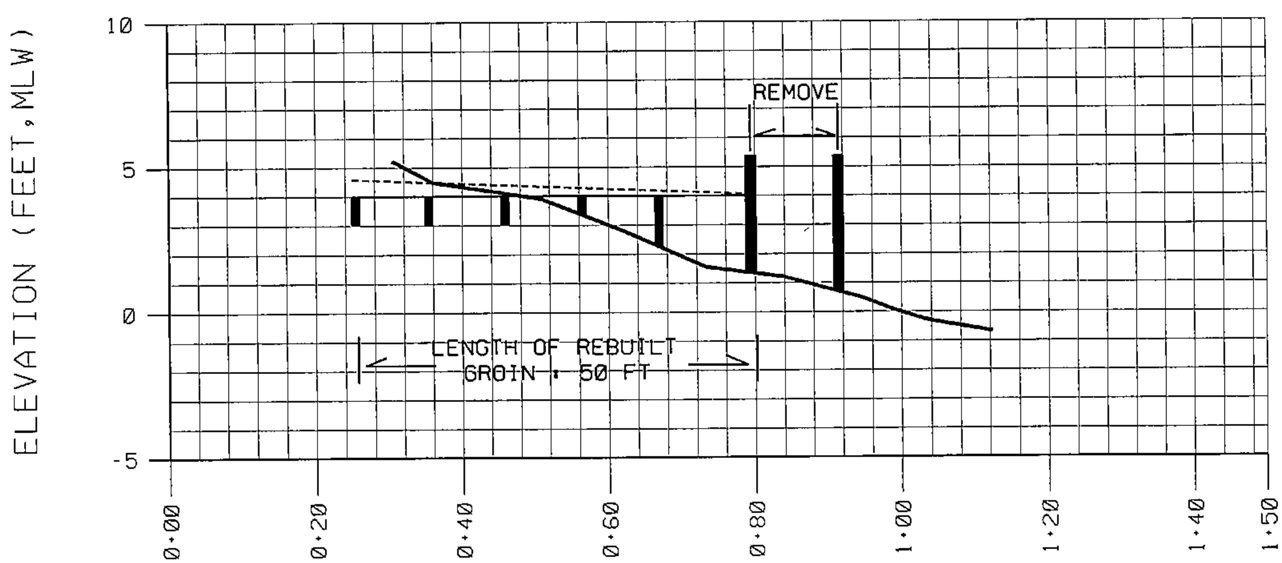
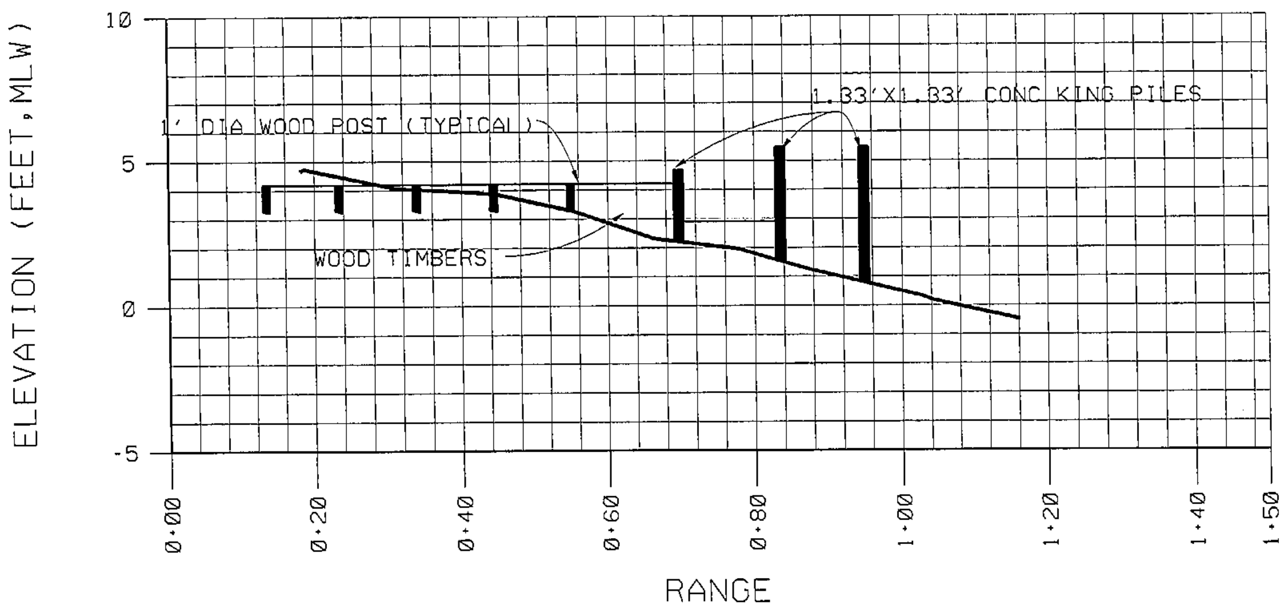


RECOMMENDED IMPROVEMENT

PLATE 6

GROIN 7



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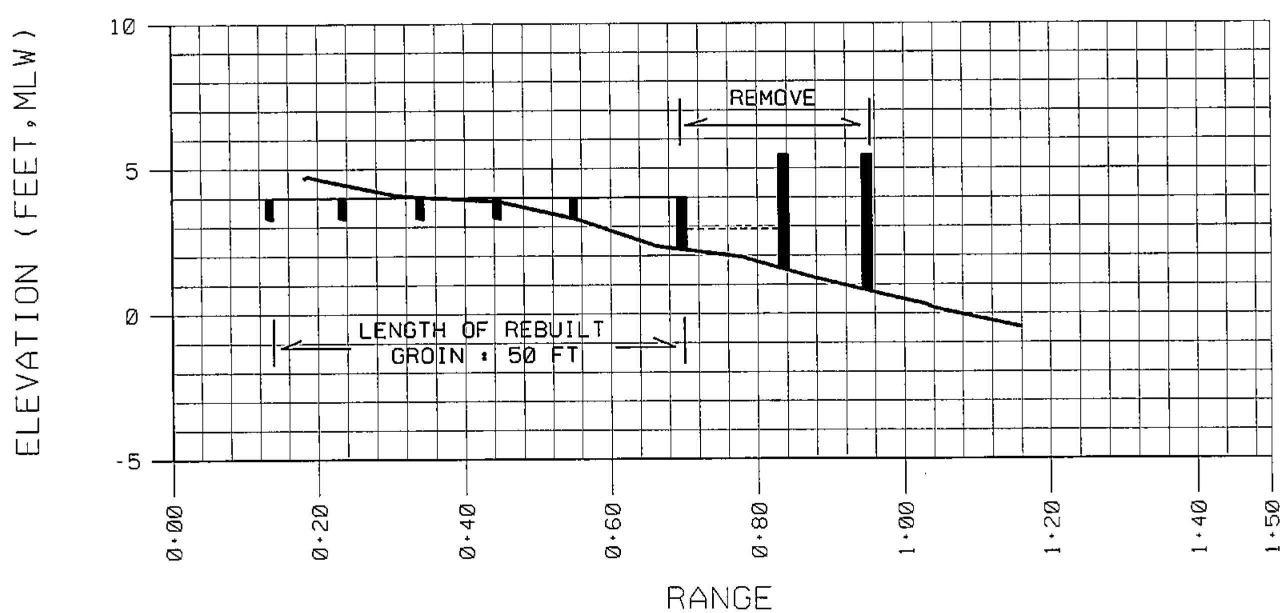
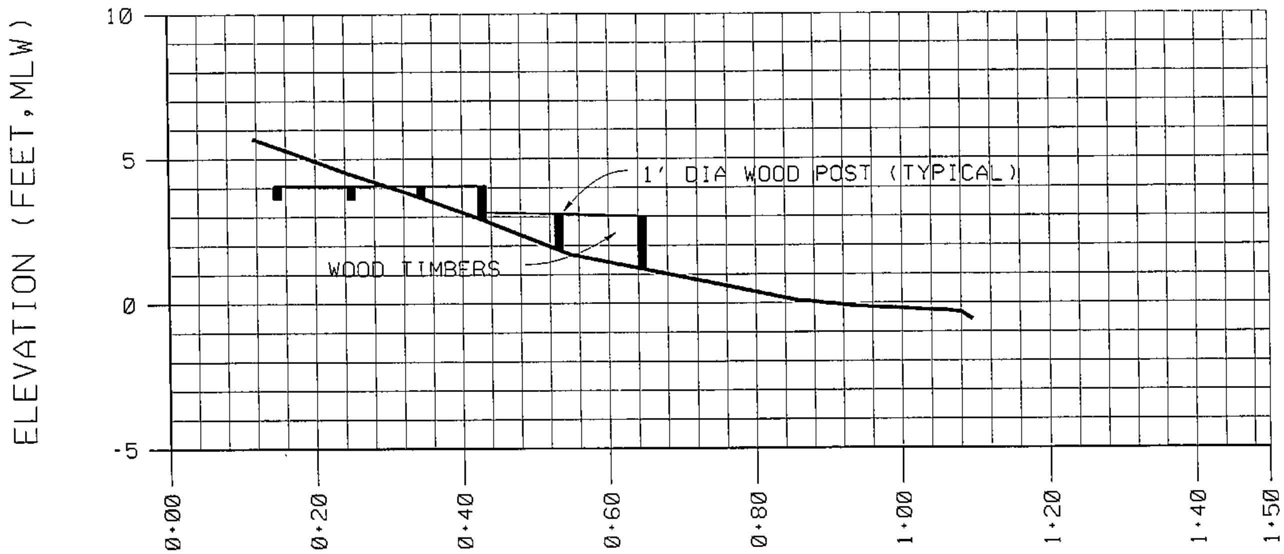


RECOMMENDED IMPROVEMENT

PLATE 7

GROIN 8



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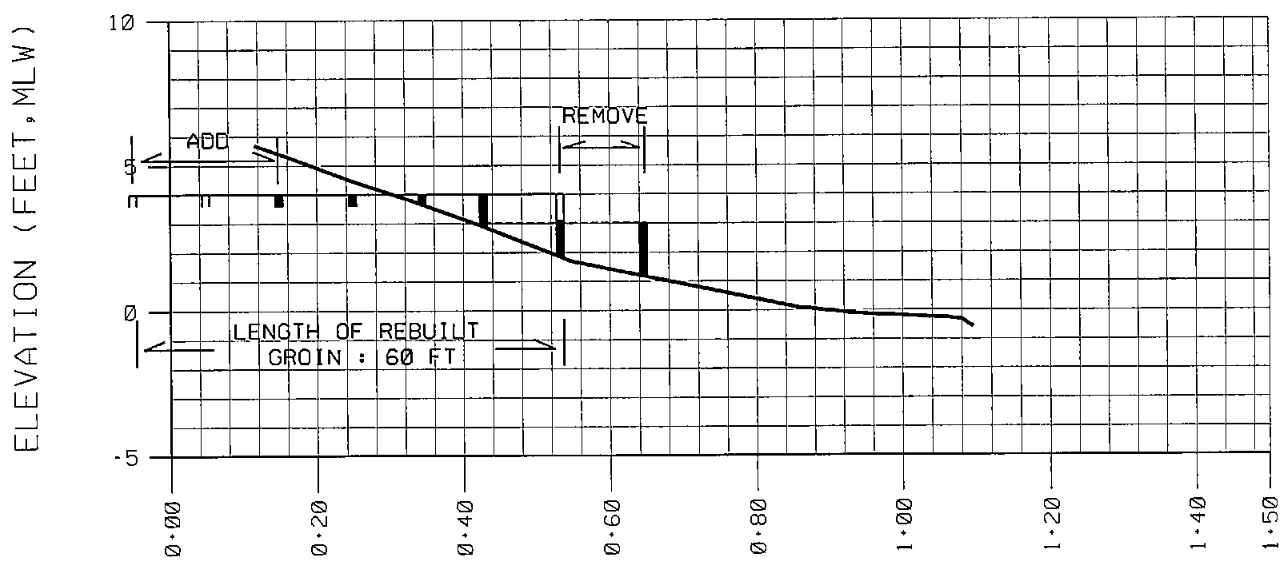
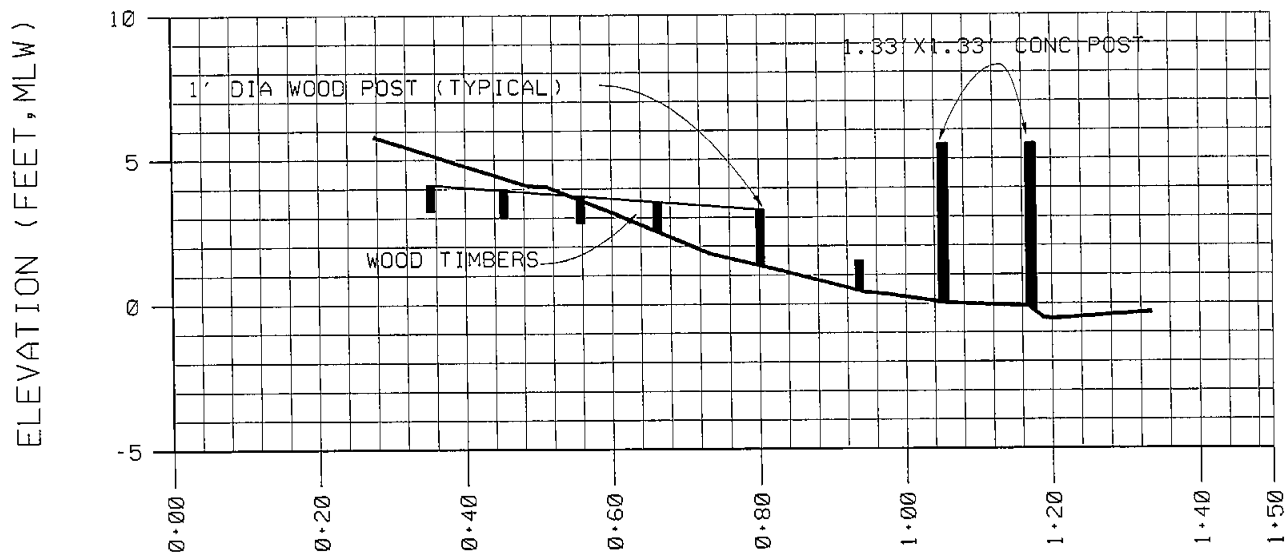


RECOMMENDED IMPROVEMENT

PLATE 8

GROIN 9



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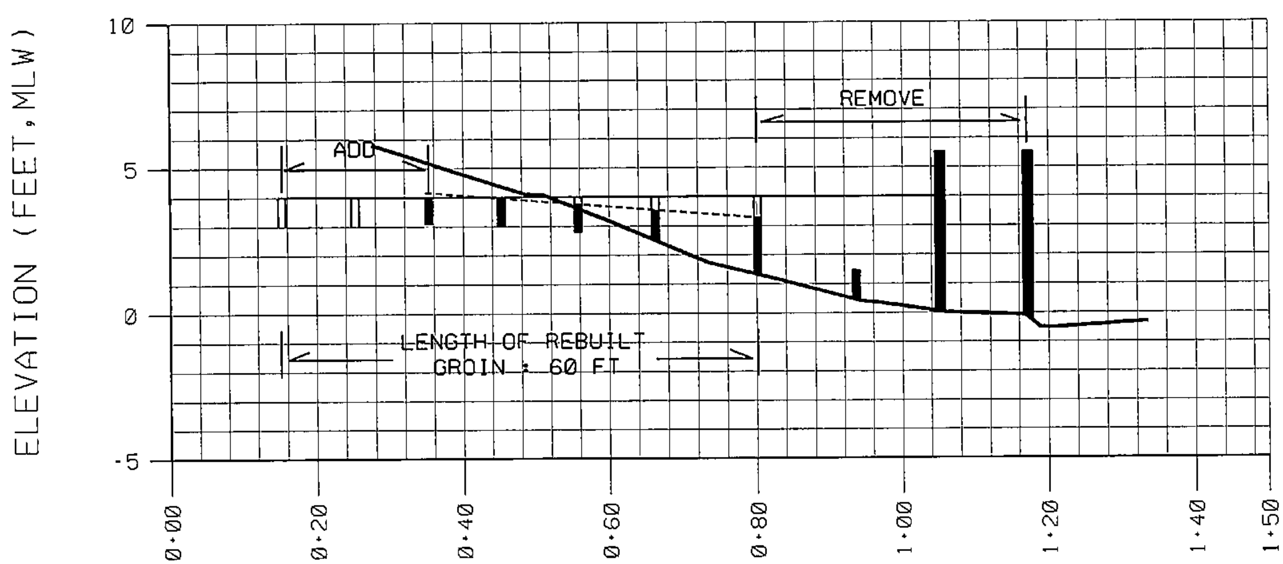
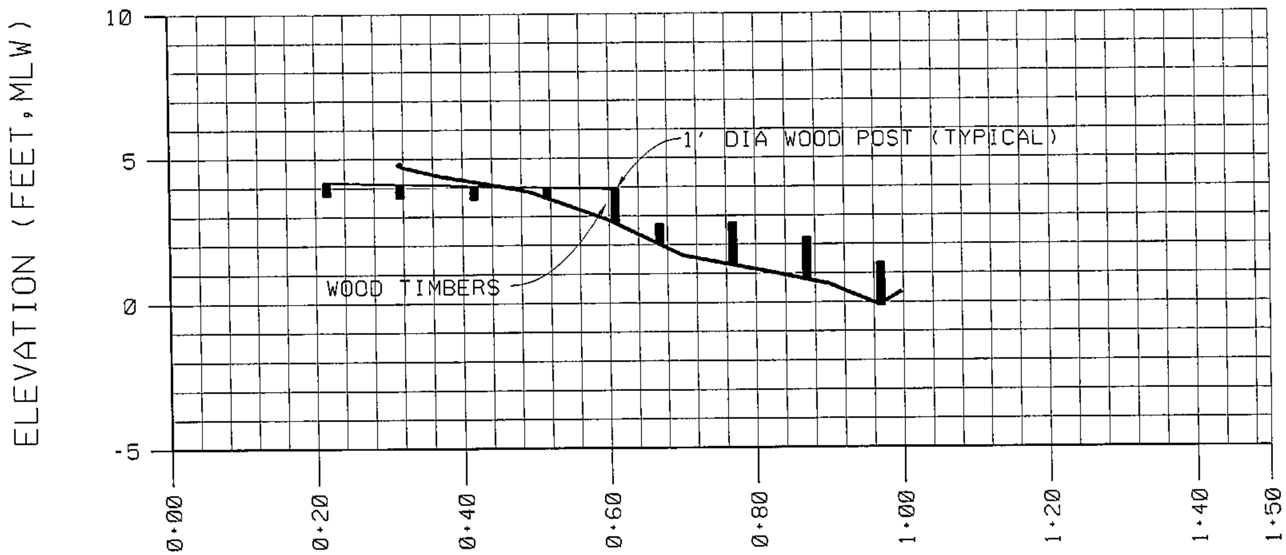


RECOMMENDED IMPROVEMENT

PLATE 9

GRO(10



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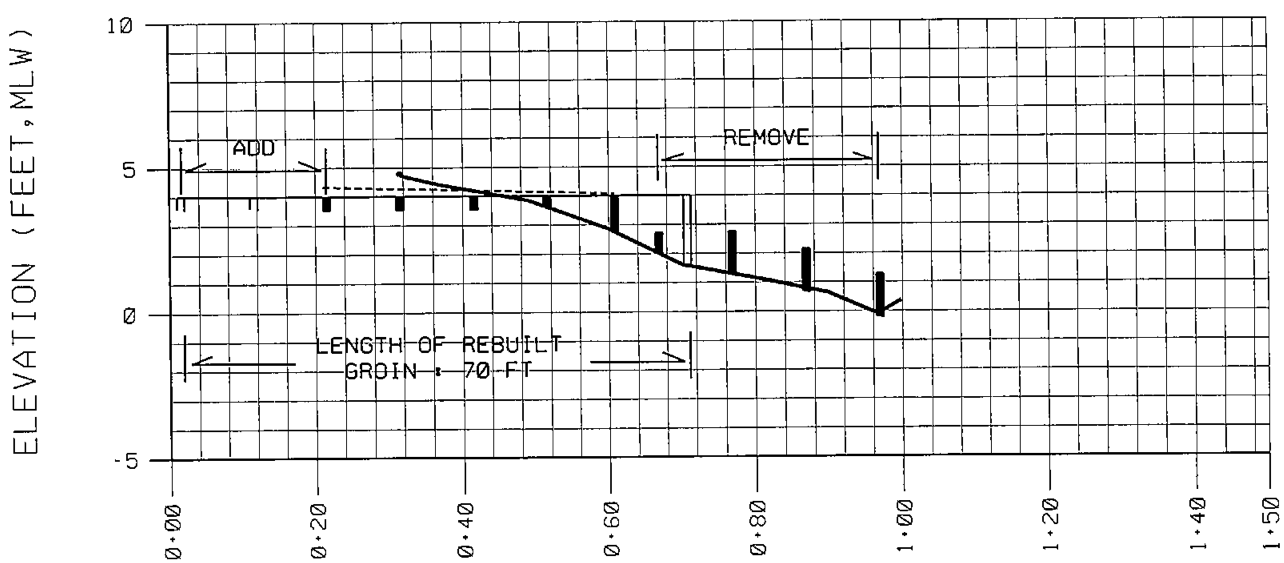
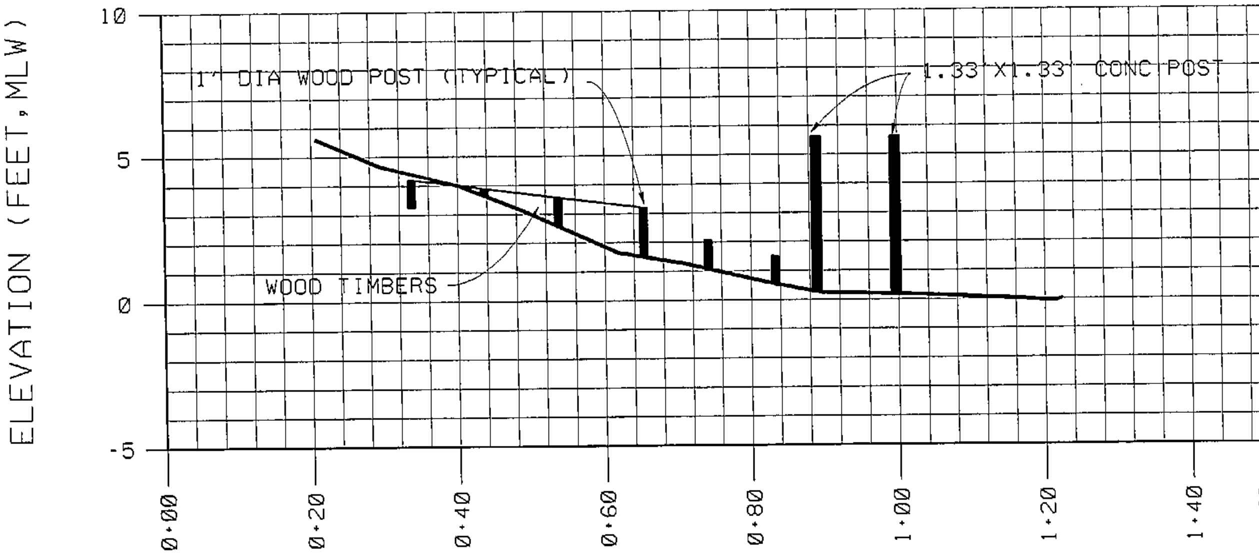


RANGE
RECOMMENDED IMPROVEMENT

PLATE 10

GROIN 11



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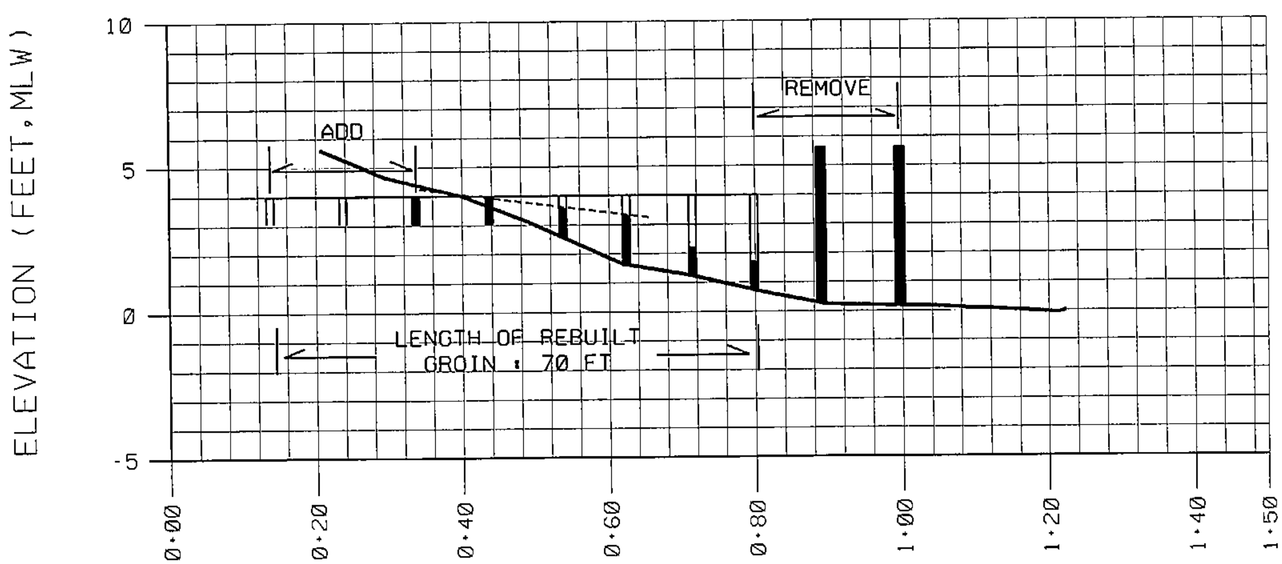
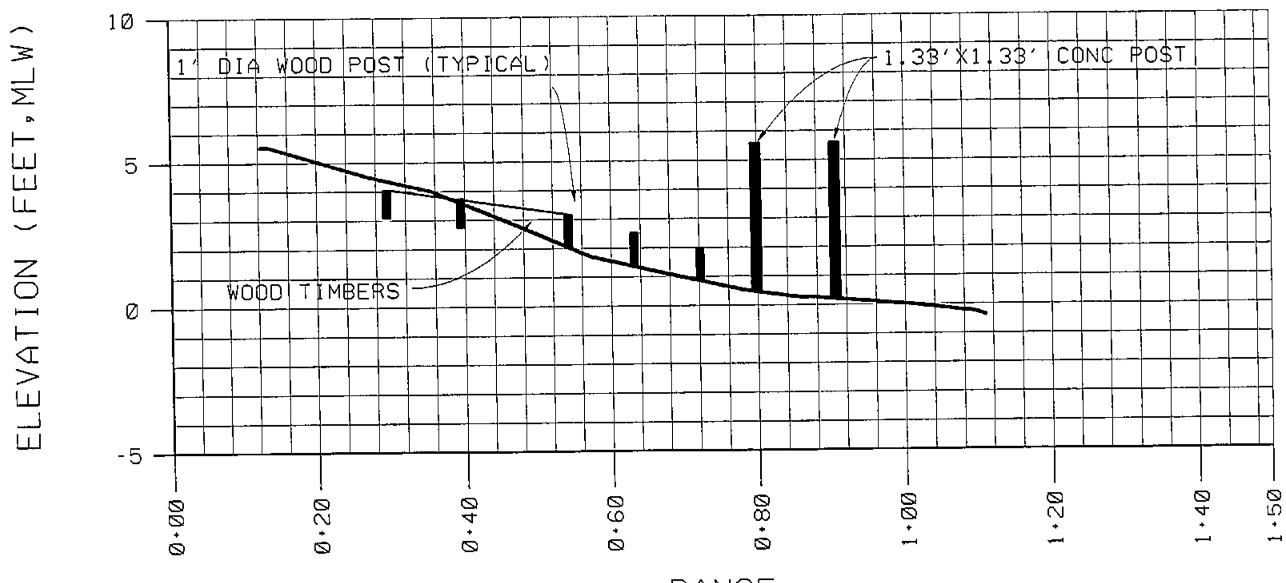


RECOMMENDED IMPROVEMENT

PLATE 11

GROIN 12



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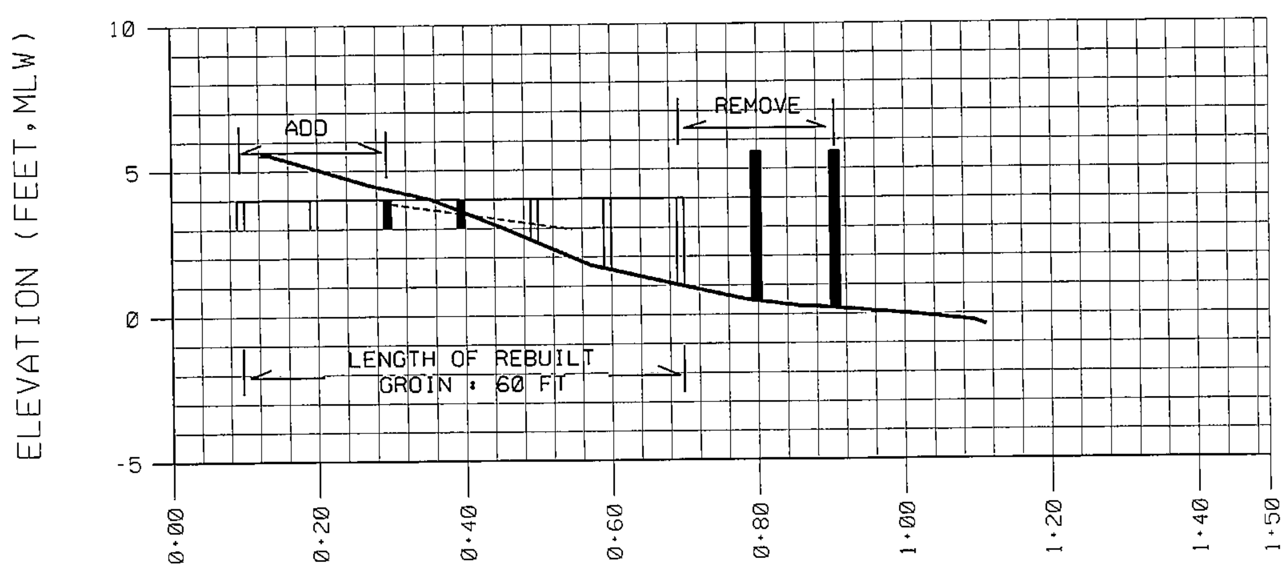
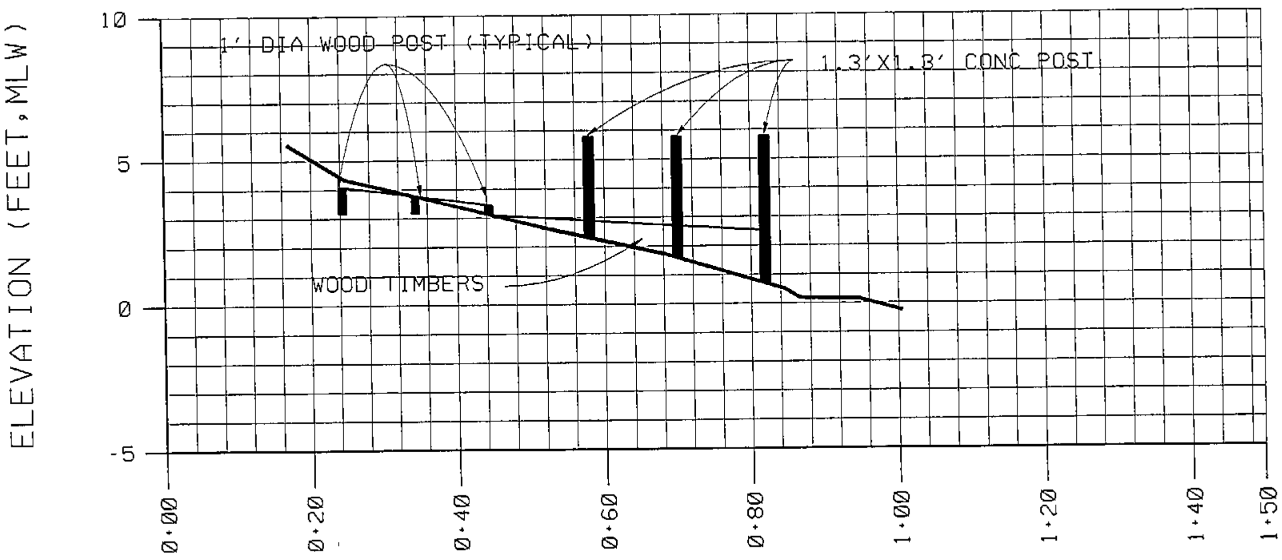


RECOMMENDED IMPROVEMENT

PLATE 12

GROIN 13



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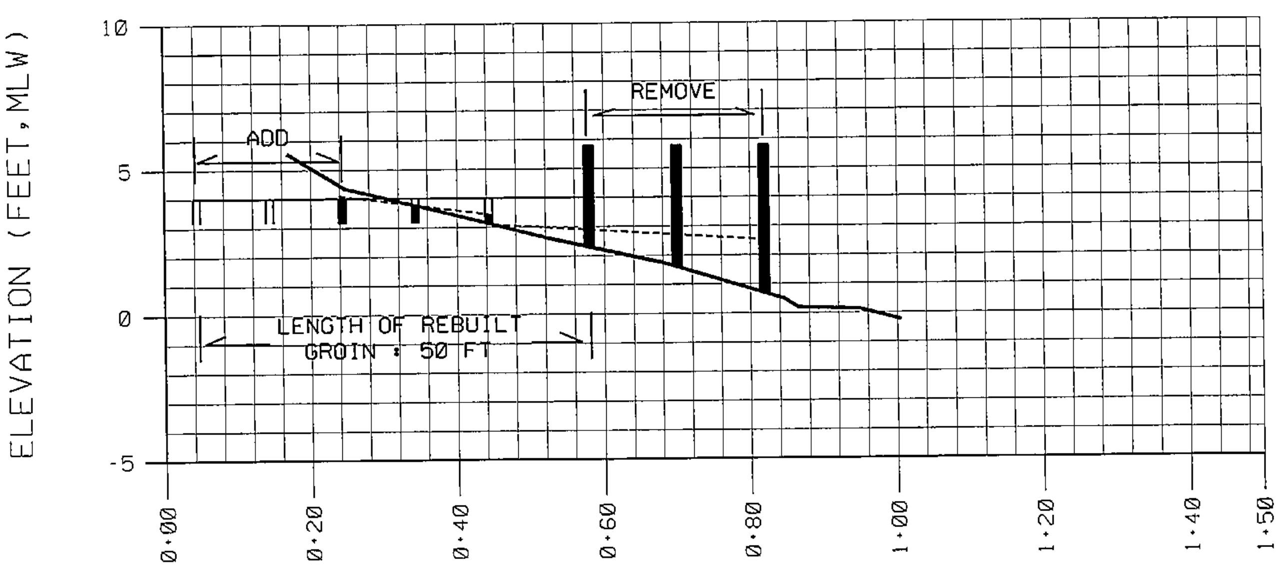
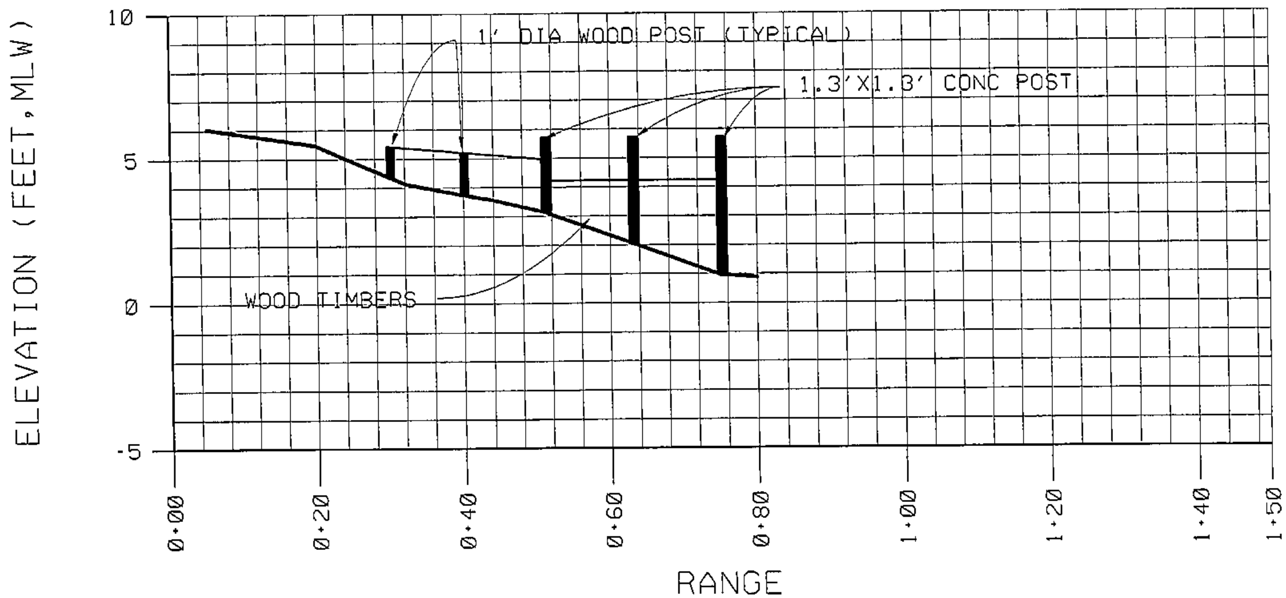


RECOMMENDED IMPROVEMENT

PLATE 13

GROIN 14



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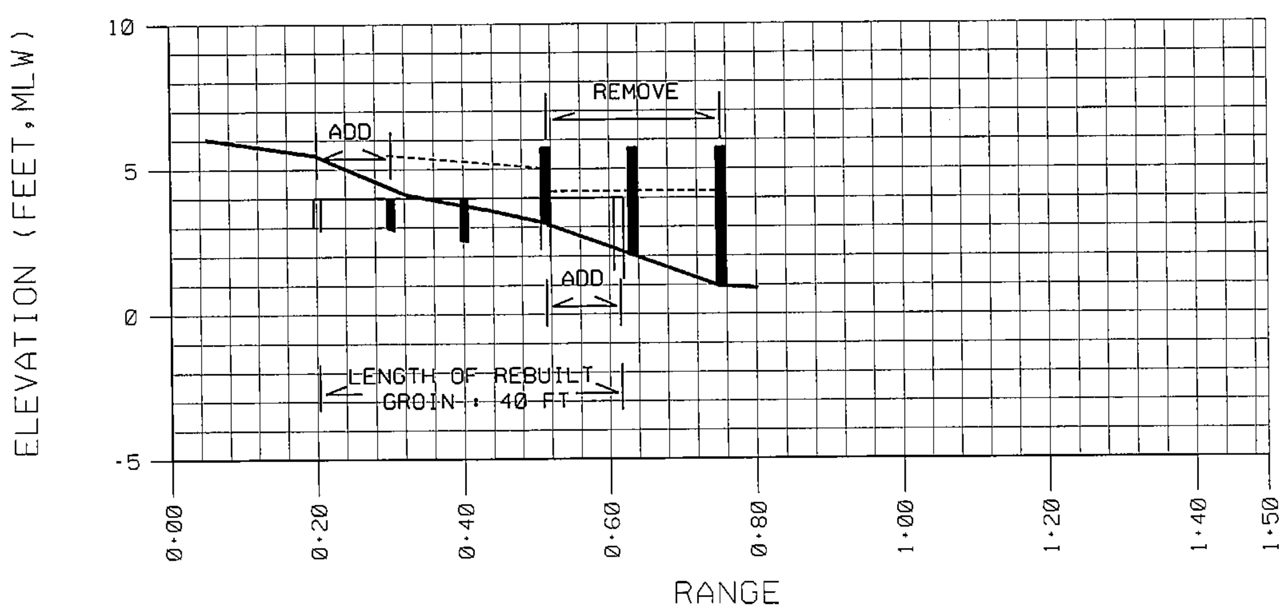
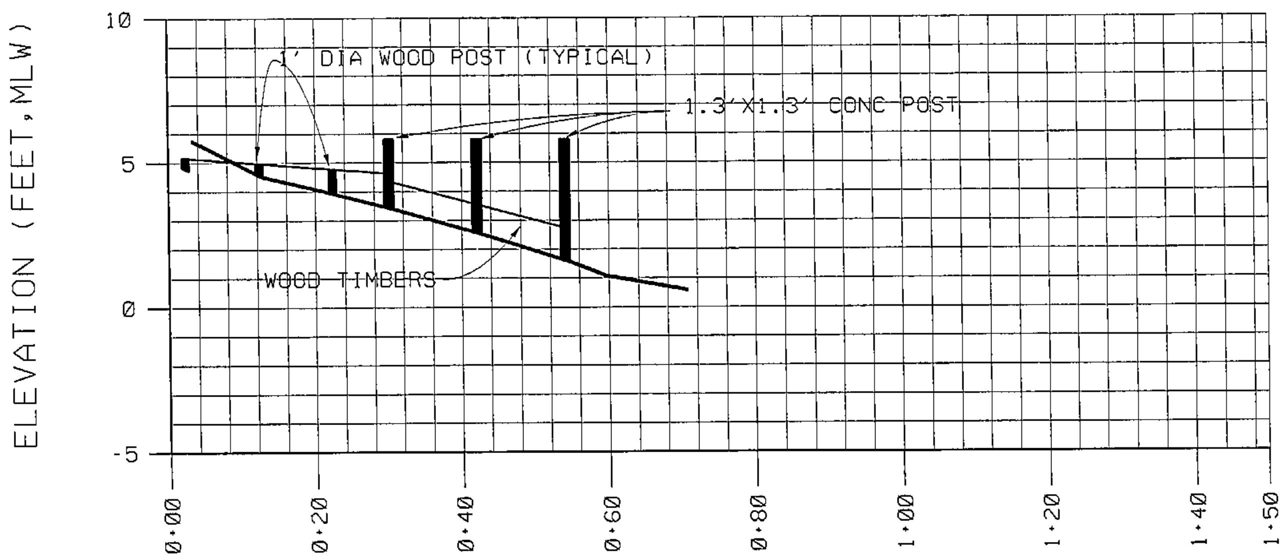


RECOMMENDED IMPROVEMENT

PLATE 14

GROIN 15



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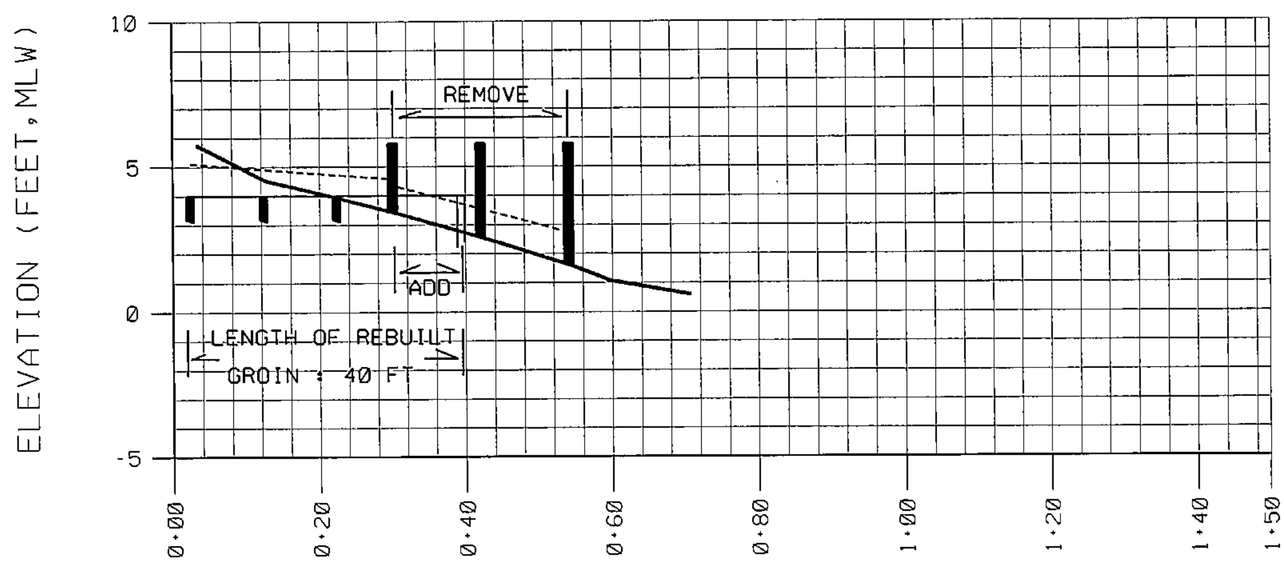
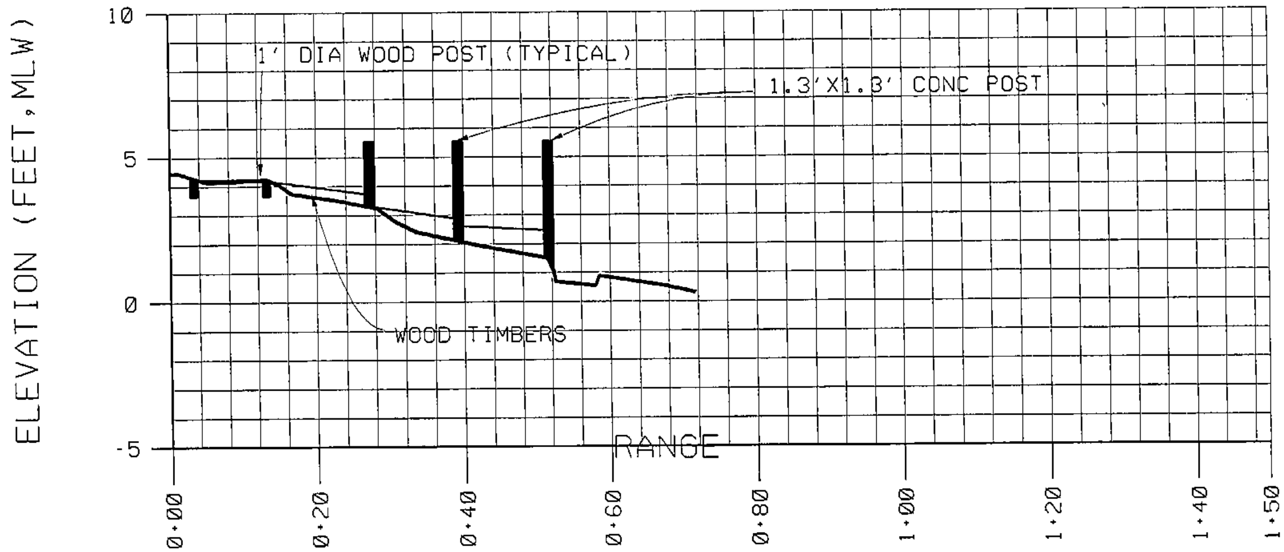


RECOMMENDED IMPROVEMENT

PLATE 15

GROIN 16



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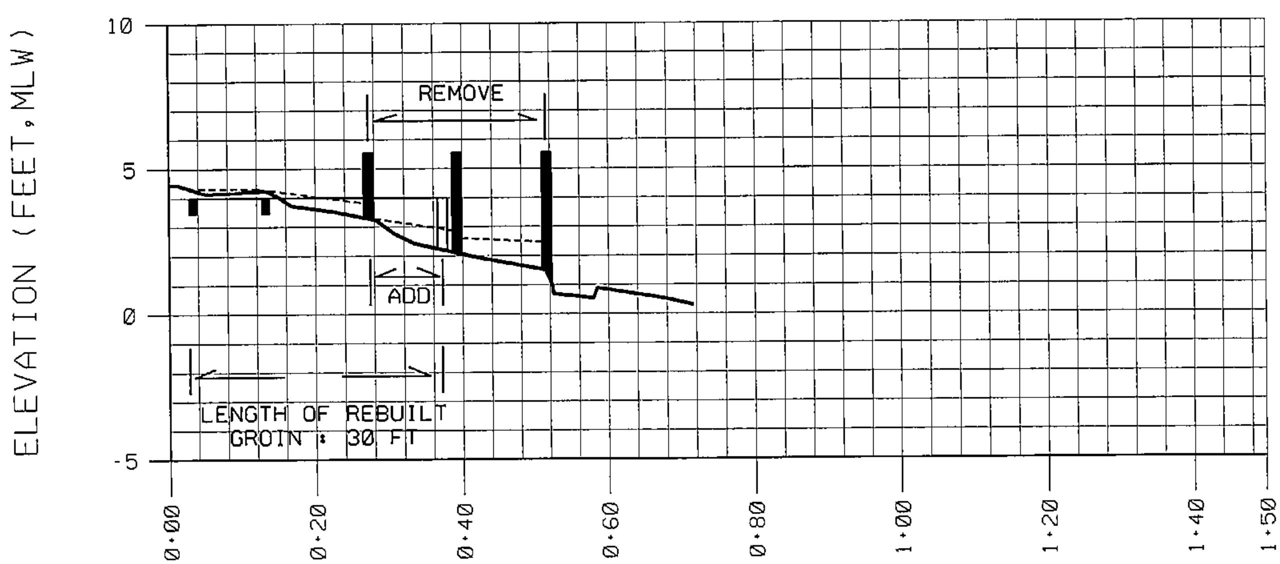
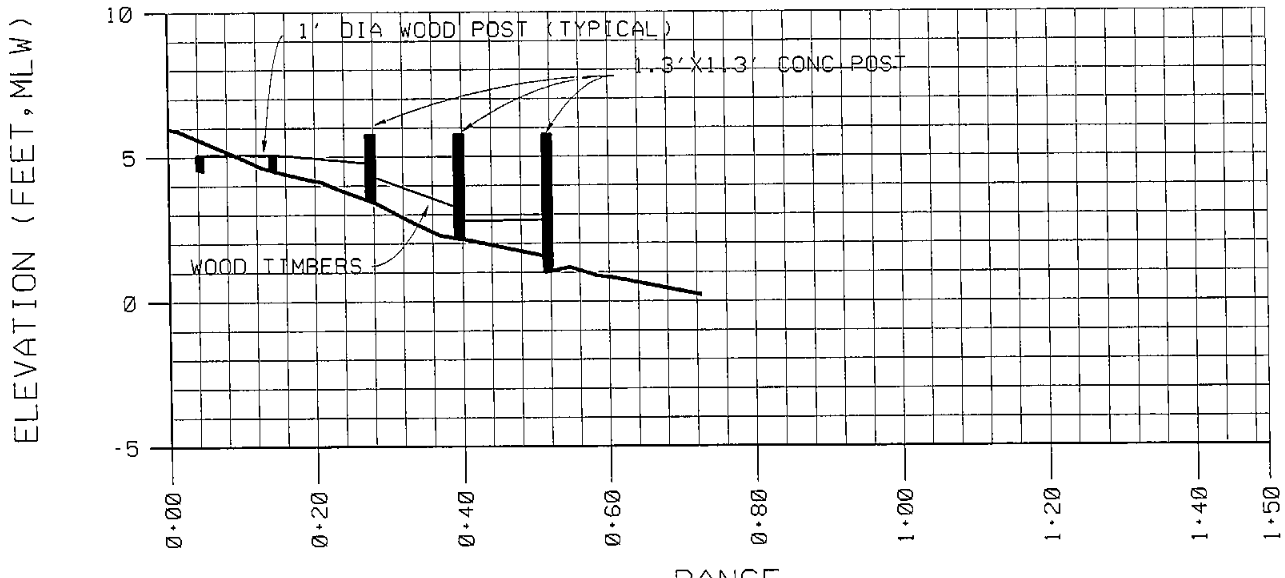


RANGE
RECOMMENDED IMPROVEMENT

PLATE 16

GROIN 17



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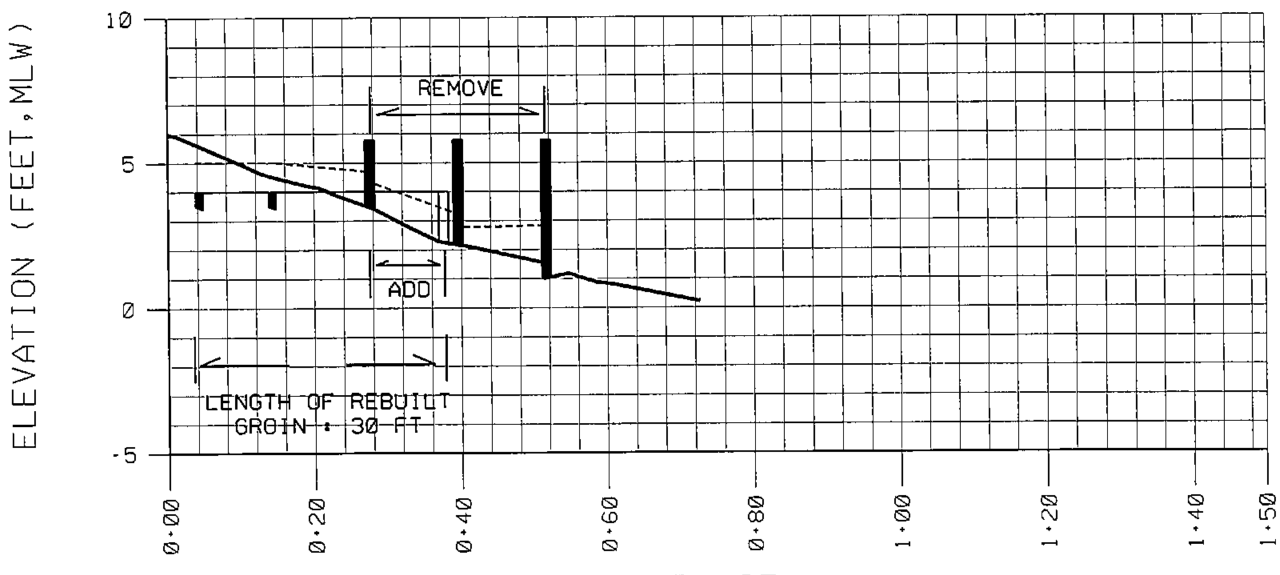
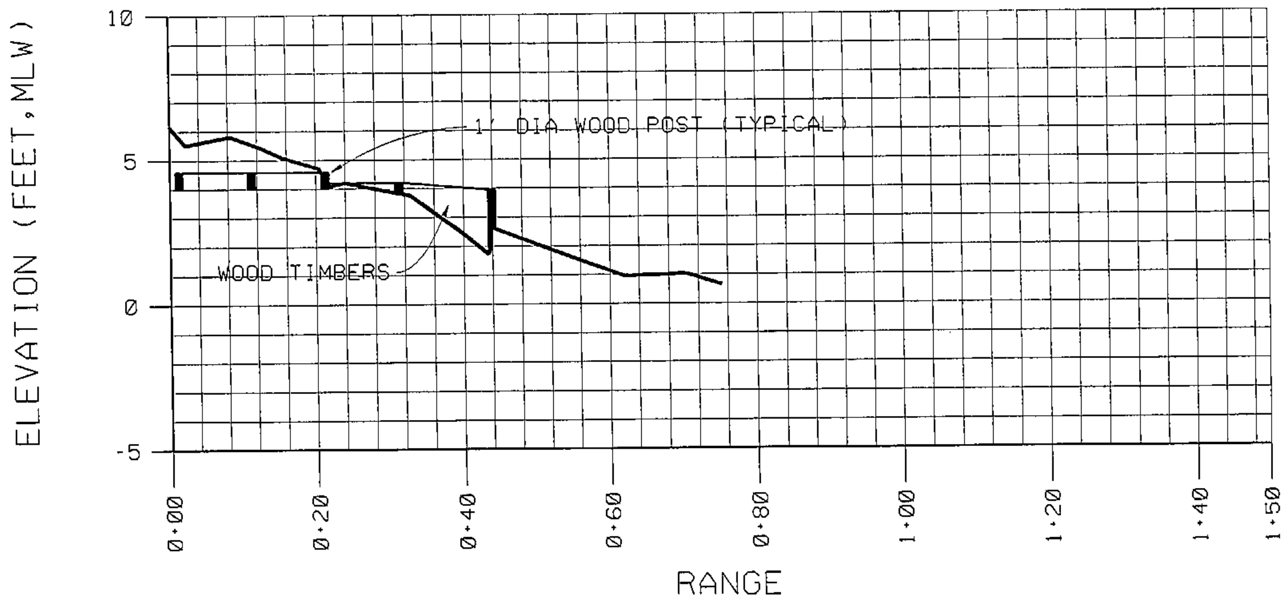


RECOMMENDED IMPROVEMENT

PLATE 17

GROIN 18



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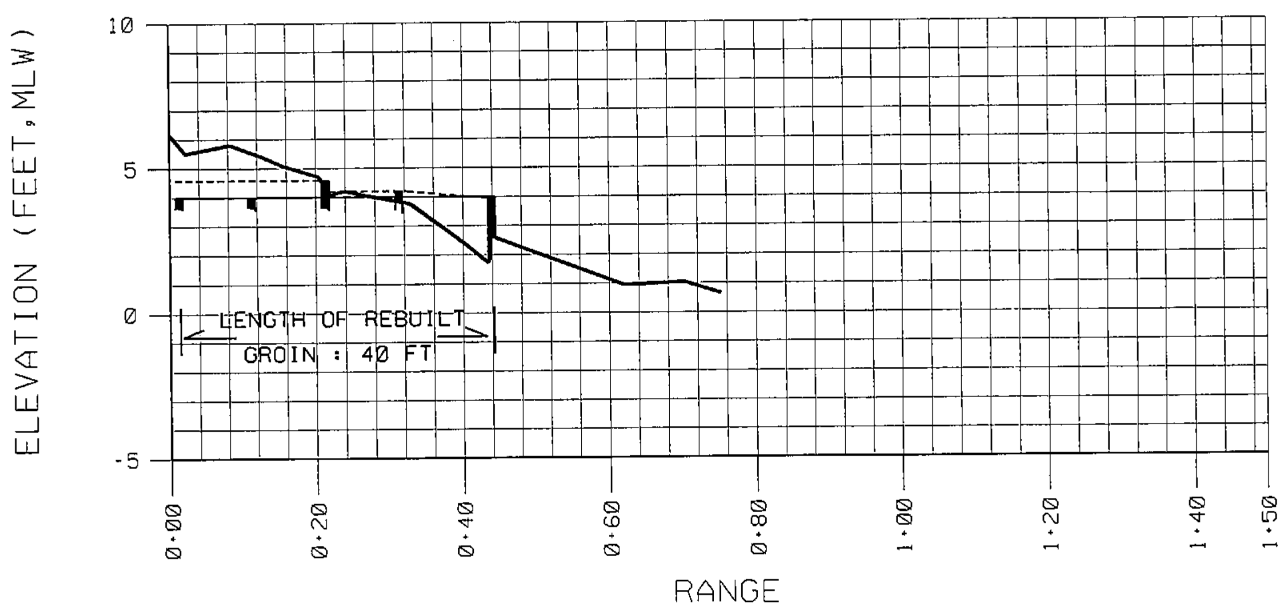
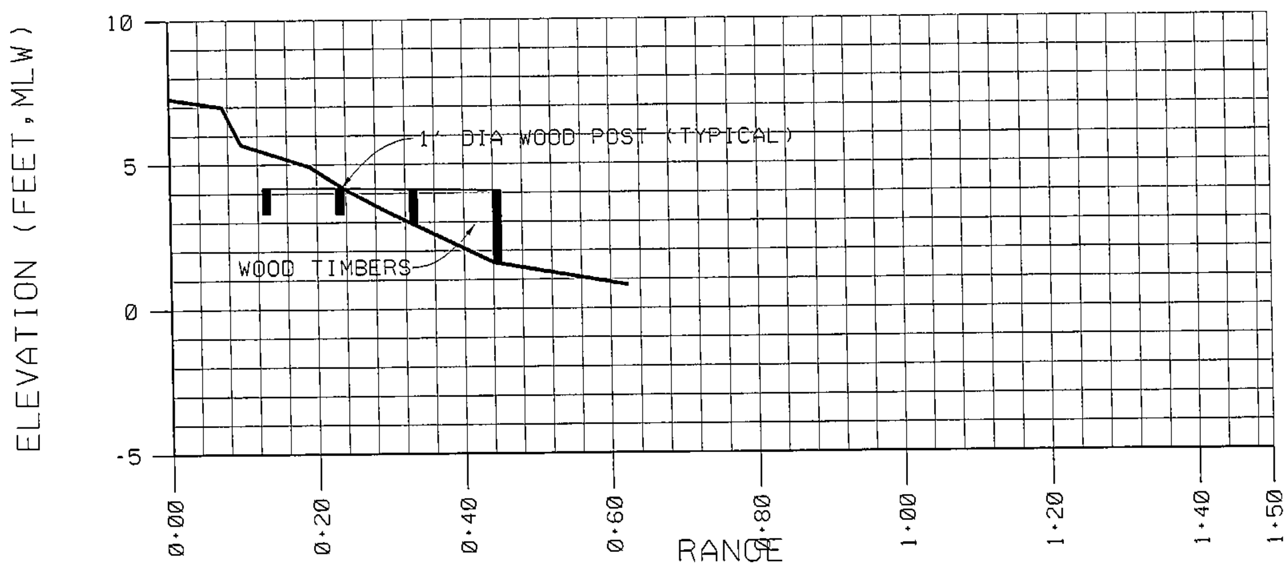


RECOMMENDED IMPROVEMENT

PLATE 18

GROIN 19



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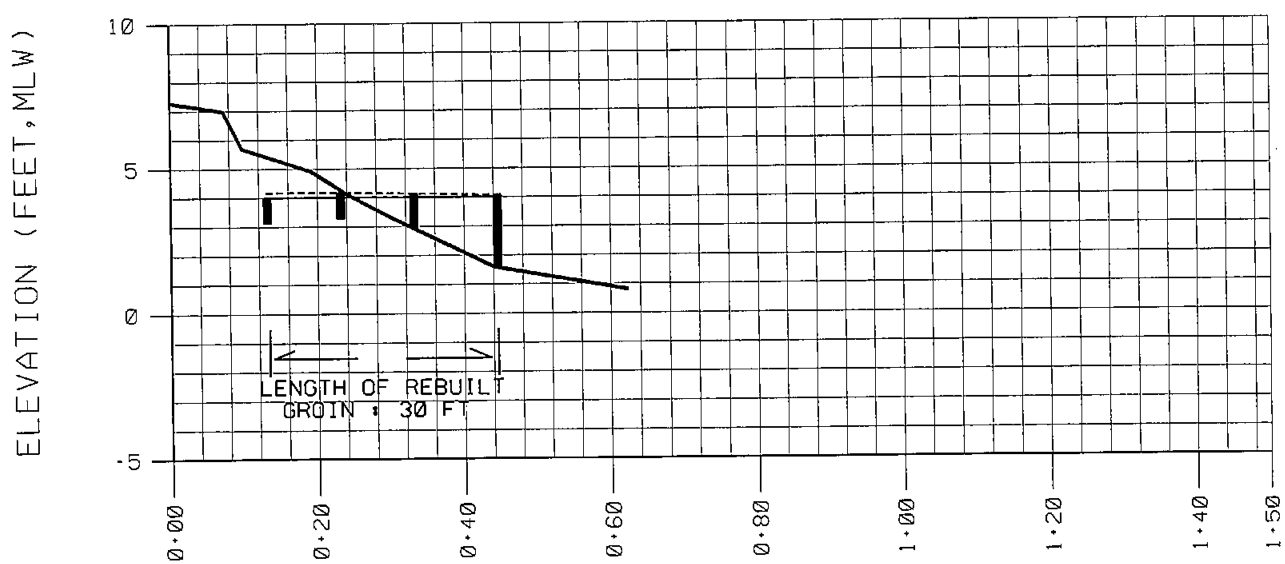
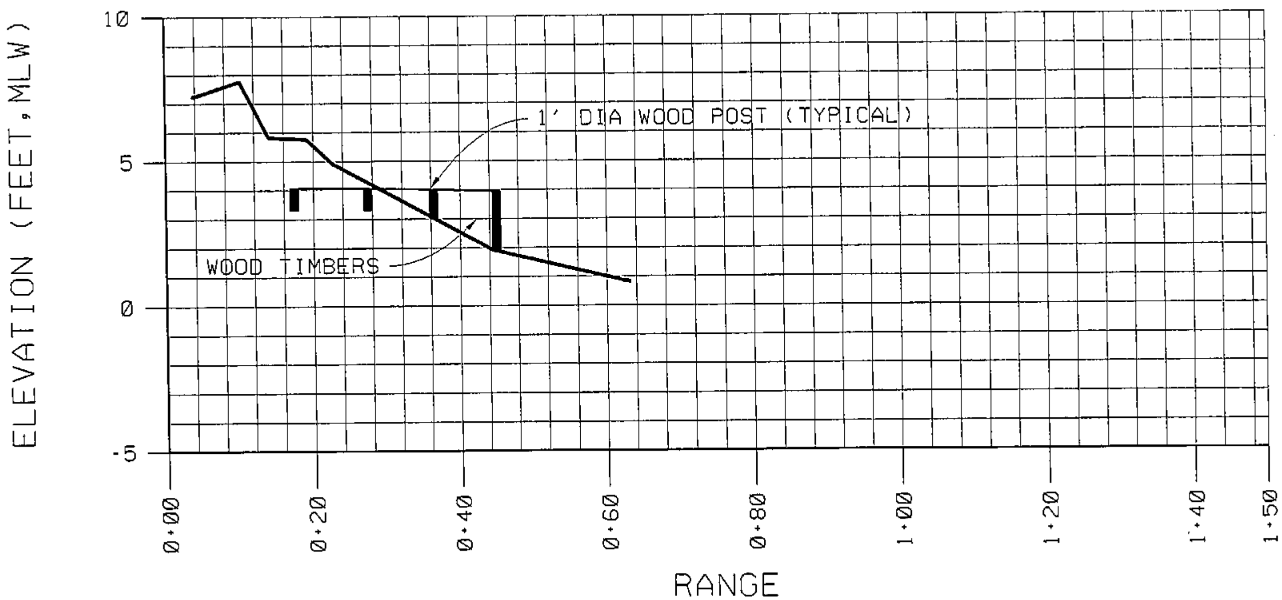


RECOMMENDED IMPROVEMENT

PLATE 19

GROIN 20



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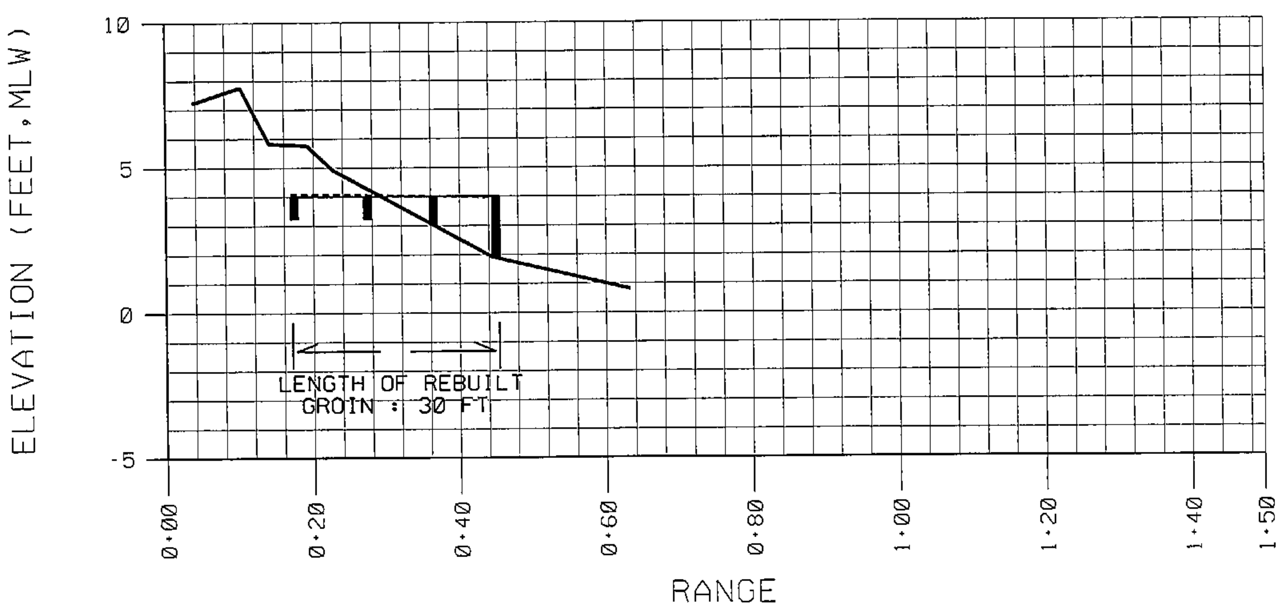
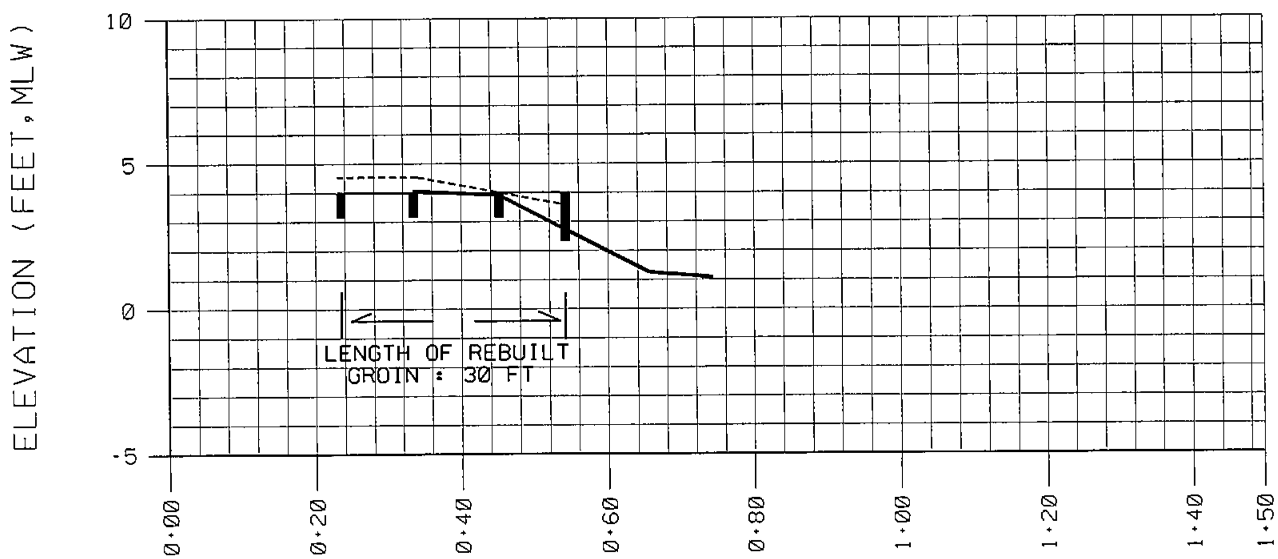


RECOMMENDED IMPROVEMENT

PLATE 20

GROIN 21

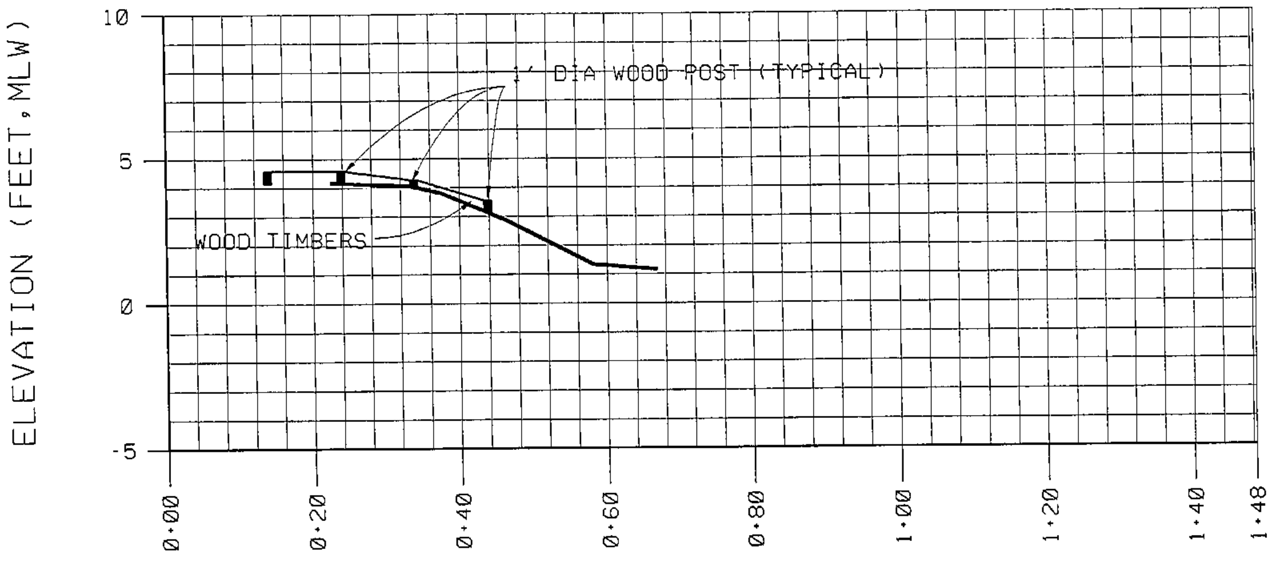
EXISTING CONDITION



RECOMMENDED IMPROVEMENT

PLATE 21

GROIN 22



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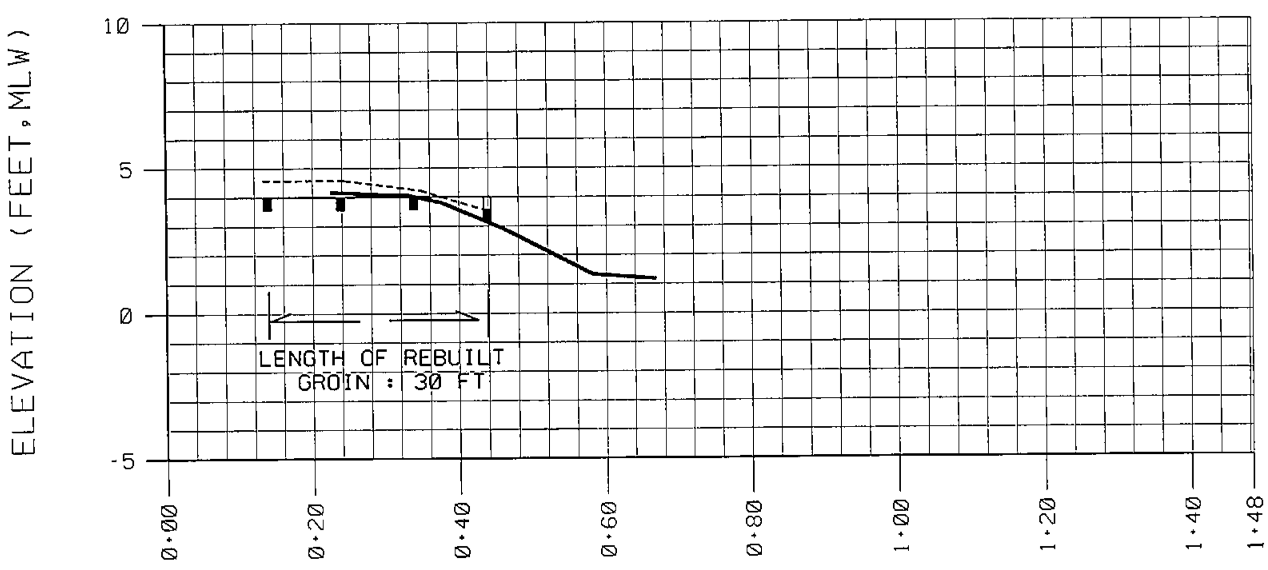
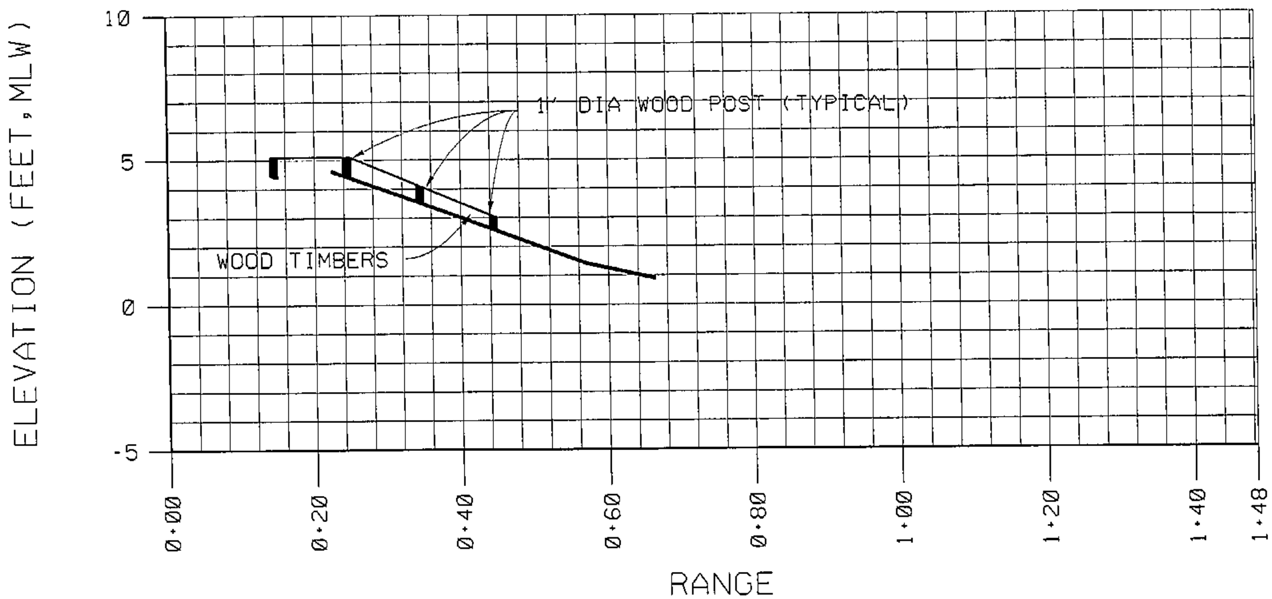


RECOMMENDED IMPROVEMENT

PLATE 22

GROIN 23



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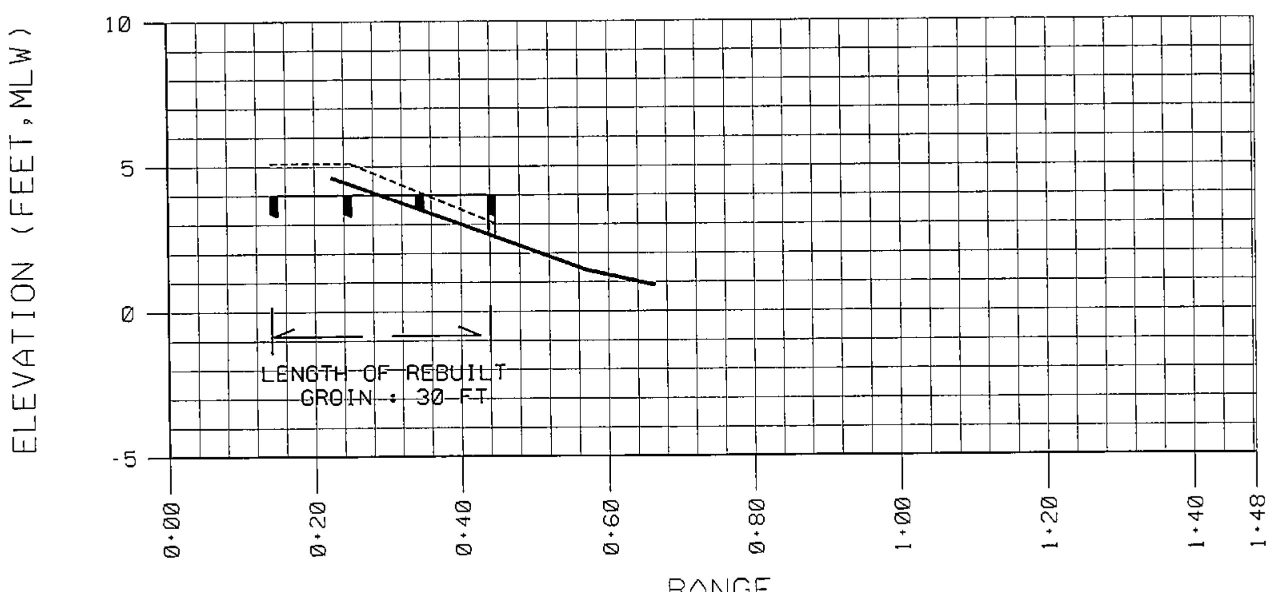
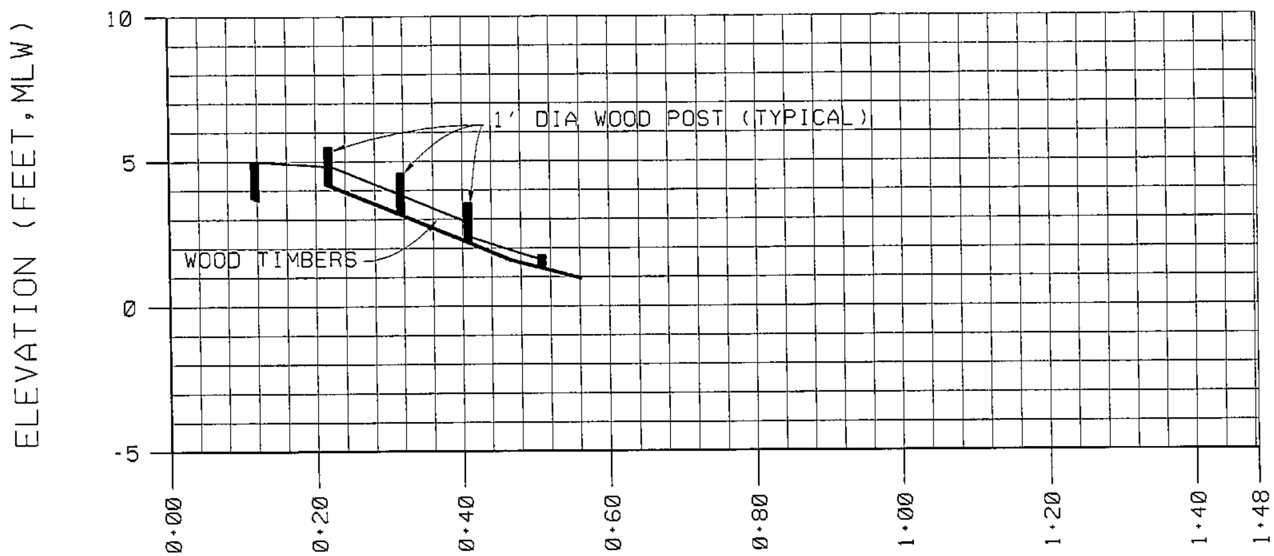


RECOMMENDED IMPROVEMENT

PLATE 23

GROIN 24



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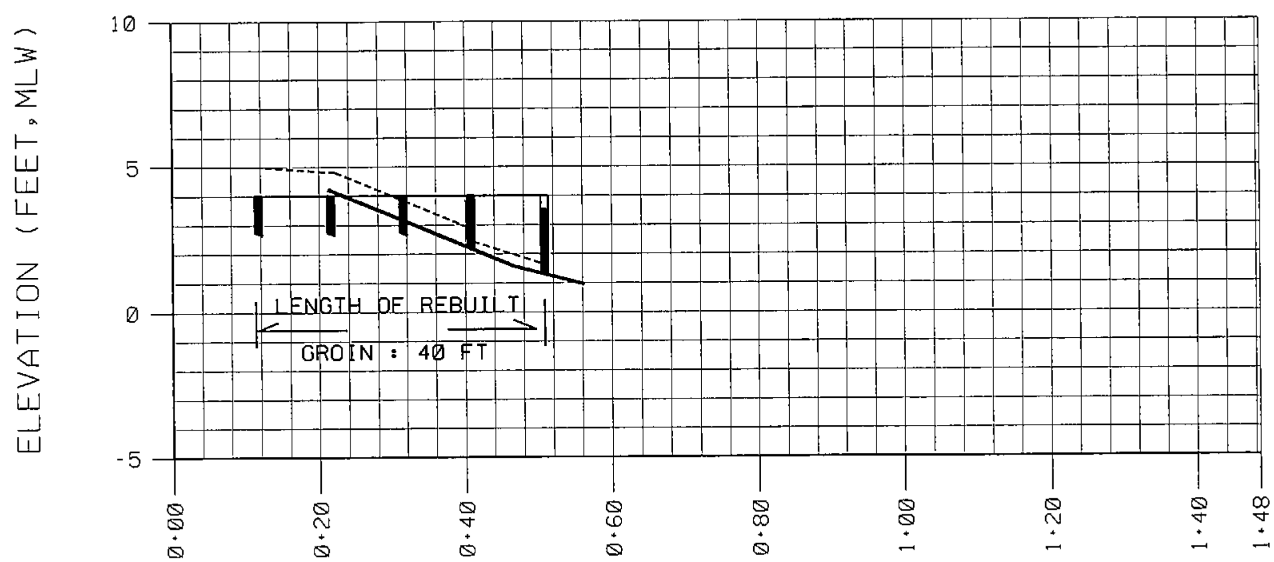
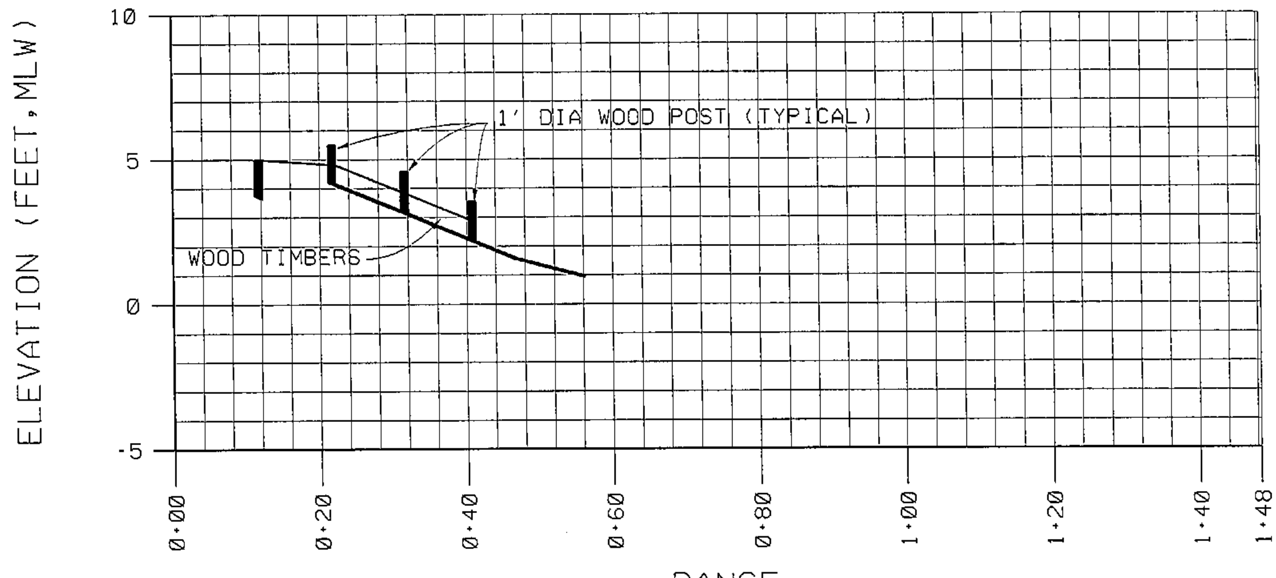


RECOMMENDED IMPROVEMENT

PLATE 24

GROIN 25



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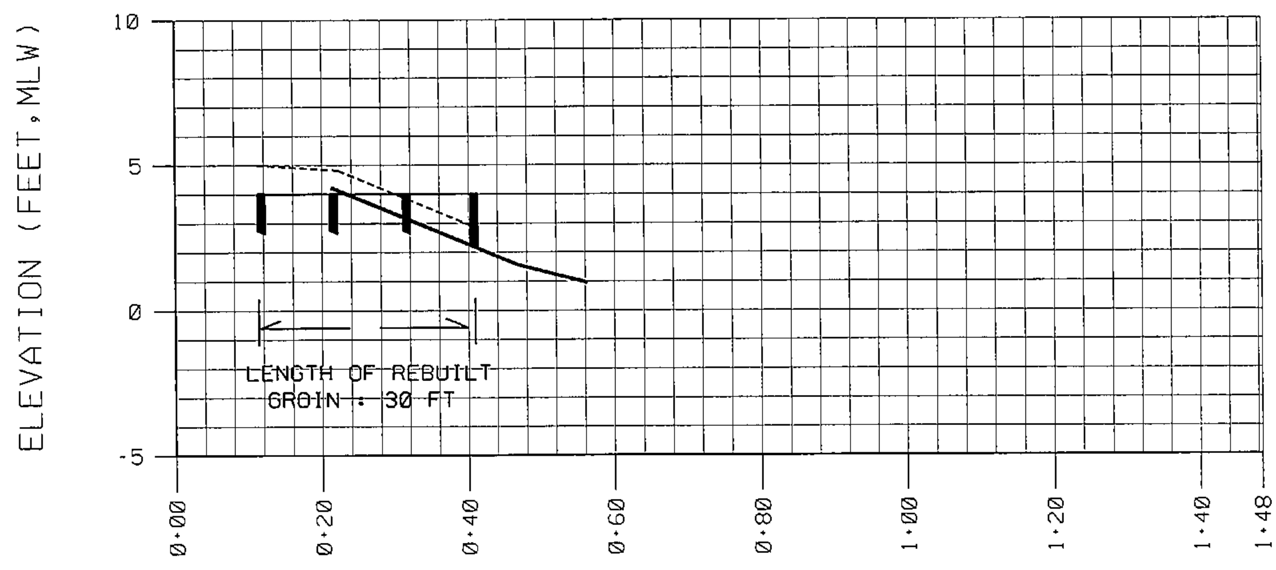


RECOMMENDED IMPROVEMENT

PLATE 25

SUB-APPENDIX A-1

M-CACES COST ESTIMATES

Virginia Key Section 111
Option 3
New Stone Groins (8)
Replace Existing Groin Field

Designed By: CESAJ
Estimated By: Anthony L. DiPiero, P.E.

Prepared By: Anthony L. DiPiero, P.E.

Preparation Date: 02/06/02
Effective Date of Pricing: 02/06/02
Est Construction Time: 360 Days

Sales Tax: 6.50%

Summary of the revised scope of Work provided by Tom Martin, EN-HC on 20 Apr 2001; then updated 4 Feb 2002

Construct 8 new groins (175'each)for a total of 1400 lf. All new groin construction will be land-based.
Shallow offshore depths and the presence of extensive nearshore seagrass beds make water-based construction (barge, etc) impractical. Due to the presence of these seagrass areas along the length of the project, turbidity containment devices will be used during any operations, which generate turbidity. Note that turbidity monitoring is incorporated into Field Overhead percentage for this phase of estimate.

Rubble-mound groins. The tons of stone required for construction were provided in table 5 of the revised draft report.

The estimate includes the cost of mitigating a total of 159,200 sq.ft of seagrass (37,050 sf for the groin construction and king pile removal, and 122,150 sf for beach fill placement). The issue of seagrass replanting was discussed with Mr. Mike Dupes. Based on information contained in a WES report from the late 1970's, the cost per square foot of plug was brought forward to today's dollars. Plug spacing is 0.5 sqft of plug on 18" centers.

Beach Fill Construction. A total of 30,500 cubic yards of beach fill will be placed along the shoreline of the County Park. Fill will be placed mechanically (not hydraulically) to minimize impacts to the adjacent seagrass areas.
Upland borrow area is adjacent to fill area. Assume that this material will NOT need to be sieved (to remove rock) OR hydrocycloned (to remove silt) prior to placement on the beach. Considerable debris (downed trees, logs, stumps, etc.) will need to be removed from the project area prior to placement of beach fill and disposed of off-site. An additional component will be the construction of a 2' high dune along the landward edge of the beach fill along the eastern 1300' of park. The total volume is 710 cy.

Removal of Concrete King Piles. 26 concrete king piles will be removed from the central portion of the existing groin field and stockpiled on site.

A total of 25 partially deteriorated timber groins along the western portion of the park will be removed (a total of 1030 lf). Instead of disposal in an approved facility, the project sponsor has requested that the timbers be set aside in a designated area of the park.

Project Owner Information:
A contingency of 20% was applied to the total contract cost.
PE&D: $ 300,000 (Per email from Tom Martin 4/18/01)
S&I was set as 10%. Estimated time for construction past NTP ~ 12 months.
As of 4 Feb 2002, NTP is expected to be issued in July, 2002. No escalation has been applied due to the short duration between this estimate and midpoint of construction.

SUMMARY REPORTS SUMMARY PAGE

No Detailed Estimate...

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 3 (Rounded to 100's) **

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work	1.00	EA	42,200	8,400	3,400	5,400	59,400
01- A/10 Breakwaters and Seawalls	1.00	EA	1,488,500	297,700	120,000	190,600	2,096,900
01- A/17 Beach Replenishment	1.00	EA	2,191,000	438,200	176,600	280,600	3,086,400
TOTAL Construction Costs	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700
TOTAL Virginia Key Section 111	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700
TOTAL Virginia Key Section 111	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work							
01- A/01.06 Mob, Demob & Preparatory Work							
01- A/01.06.06 Mob, Demob & Preparatory Work	1.00	EA	42,200	8,400	3,400	5,400	59,400
TOTAL Mob, Demob & Preparatory Work	1.00	EA	42,200	8,400	3,400	5,400	59,400
TOTAL Mob, Demob & Preparatory Work	1.00	EA	42,200	8,400	3,400	5,400	59,400
01- A/10 Breakwaters and Seawalls							
01- A/10.01 Breakwaters and Seawalls							
01- A/10.01.01 Remove Existing Groin Field	10.30	CLF	44,200	8,800	3,600	5,700	62,300
01- A/10.01.02 Conc. Pile Removal	26.00	EA	39,400	7,900	3,200	5,000	55,500
01- A/10.01.03 Stone Groins	14.00	CLF	775,500	155,100	62,500	99,300	1,092,400
01- A/10.01.99 Re-Plant Sea Grass	37050.00	SF	629,400	125,900	50,700	80,600	886,600
TOTAL Breakwaters and Seawalls	1.00	EA	1,488,500	297,700	120,000	190,600	2,096,900
TOTAL Breakwaters and Seawalls	1.00	EA	1,488,500	297,700	120,000	190,600	2,096,900
01- A/17 Beach Replenishment							
01- A/17.00 Beach Replenishment							
01- A/17.00.02 Place Beach Fill	30.50	MCY	103,900	20,800	8,400	13,300	146,300
01- A/17.00.03 Re-Plant Sea Grass	122150.00	SF	2,075,100	415,000	167,300	265,700	2,923,100
01- A/17.00.76 Construct 2' high berm	710.00	CY	2,700	500	200	300	3,800
01- A/17.00.99 Debris Clearing & Disposal	1.00	EA	9,400	1,900	800	1,200	13,200
TOTAL Beach Replenishment	1.00	EA	2,191,000	438,200	176,600	280,600	3,086,400
TOTAL Beach Replenishment	1.00	EA	2,191,000	438,200	176,600	280,600	3,086,400
TOTAL Construction Costs	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700
TOTAL Virginia Key Section 111	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700
TOTAL Virginia Key Section 111	1.00	EA	3,721,700	744,300	300,000	476,600	5,242,700

No errors detected...

* * * END OF ERROR REPORT * * *

Virginia Key Section 111
Option 5A
New Timber Groins (3)
Rebuild Existing Groin Field

Designed By: CESAJ
Estimated By: Anthony L. DiPiero, P.E.

Prepared By: Anthony L. DiPiero, P.E.

Preparation Date: 02/06/02
Effective Date of Pricing: 02/06/02
Est Construction Time: 360 Days

Sales Tax: 6.50%

Summary of the scope of Work provided by Tom Martin, EN-HC on 4 Apr 2001; then updated 4 Feb 2002.

Construct 3 new groins (350 lf) along the eastern end of the County Park as well as 25 new timber groins (1190 lf) for a total of 1540 lf. All new groin construction will be land-based. Shallow offshore depths and the presence of extensive nearshore seagrass beds make water-based construction (barge, etc) impractical.

Due to the presence of these seagrass areas along the length of the project, turbidity containment devices will be used during any operations, which generate turbidity. Note that turbidity monitoring is incorporated into Field Overhead percentage for this phase of estimate.

The timber groins would be constructed using the timber groin design previously provided to EN-C. The quantities of materials are provided in table 11a of the report. CCA-treated lumber is to be used in place of the creosote-treated lumber specified in the report. The estimate includes the cost of mitigating 850 sq.ft of seagrass (500 sqft from the kingpiles and 350 sqft from groin construction). The issue of seagrass replanting was discussed with Mr. Mike Dupes. Based on information contained in a WES report from the late 1970's, the cost per square foot of plug was brought forward to today's dollars. Plug spacing is 0.5 sqft of plug on 18" centers.

Beach Fill Construction. A total of 8,050 cubic yards of beach fill will be placed along a 1,300-ft reach of eroded shoreline along the eastern portion of the County Park. Fill will be placed mechanically (not hydraulically) to minimize impacts to the adjacent seagrass areas. Upland borrow area is adjacent to fill area.
Assume that this material will NOT need to be sieved (to remove rock) OR hydrocycloned (to remove silt) prior to placement on the beach. Considerable debris (downed trees, logs, stumps, etc.) will need to be removed from the project area prior to placement of beach fill and disposed of off-site. The cost estimate includes the cost of mitigating 7,440 sq. ft of seagrass due to placement of the beach fill. An additional component will be the construction of a 2' high dune along the landward edge of the beach fill along the eastern 1300' of park. The total volume is 710 cy.

Removal of Concrete King Piles. 26 concrete king piles will be removed from the central portion of the existing groin field and stockpiled on site.

A total of 25 partially deteriorated timber groins along the western portion of the park will be removed (a total of 1030 lf). Instead of disposal in an approved facility, the sponsor has requested the timbers be set aside in a designated area of the park.

Project Owner Information:
A contingency of 25% was applied to the total contract cost.
PE&D: $ 300,000 (Per email from Tom Martin 4/18/01)
S&I was set as 10%. Estimated time for construction past NTP is 12 months.
As of 4 Feb 2002, NTP is expected to be issued in July, 2002. No escalation has been applied due to the short duration between this estimate and midpoint of construction.

No Detailed Estimate...

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	10,600	4,700	51,600
01- A/10 Breakwaters and Seawalls	1.00	EA	625,800	156,400	227,900	101,000	1,111,100
01- A/17 Beach Replenishment	1.00	EA	169,100	42,300	61,600	27,300	300,200
TOTAL Construction Costs	1.00	EA	823,900	206,000	300,000	133,000	1,462,900
TOTAL Virginia Key Section 111	1.00	EA	823,900	206,000	300,000	133,000	1,462,900
TOTAL Virginia Key Section 111	1.00	EA	823,900	206,000	300,000	133,000	1,462,900

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work							
01- A/01.06 Mob, Demob & Preparatory Work							
01- A/01.06.01 Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	10,600	4,700	51,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	10,600	4,700	51,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	10,600	4,700	51,600
01- A/10 Breakwaters and Seawalls							
01- A/10.00 Breakwaters and Seawalls							
01- A/10.00.01 Remove Existing Groin Field	10.30	CLF	44,200	11,000	16,100	7,100	78,500
01- A/10.00.02 Conc. Pile Removal	26.00	EA	39,400	9,900	14,400	6,400	70,000
01- A/10.00.03 New Timber Groins (A-C/1-24)	15.40	CLF	527,700	131,900	192,100	85,200	937,000
01- A/10.00.04 Re-Plant Sea Grass	850.00	SF	14,400	3,600	5,300	2,300	25,600
TOTAL Breakwaters and Seawalls	1.00	EA	625,800	156,400	227,900	101,000	1,111,100
TOTAL Breakwaters and Seawalls	1.00	EA	625,800	156,400	227,900	101,000	1,111,100
01- A/17 Beach Replenishment							
01- A/17.00 Beach Replenishment							
01- A/17.00.20 Re-Plant Sea Grass	7440.00	SF	126,400	31,600	46,000	20,400	224,400
01- A/17.00.70 Place Beach Fill	8050.00	CY	30,600	7,700	11,100	4,900	54,300
01- A/17.00.75 Construct 2' high berm	710.00	CY	2,700	700	1,000	400	4,800
01- A/17.00.99 Debris Clearing & Disposal	1.00	EA	9,400	2,300	3,400	1,500	16,700
TOTAL Beach Replenishment	1.00	EA	169,100	42,300	61,600	27,300	300,200
TOTAL Beach Replenishment	1.00	EA	169,100	42,300	61,600	27,300	300,200
TOTAL Construction Costs	1.00	EA	823,900	206,000	300,000	133,000	1,462,900
TOTAL Virginia Key Section 111	1.00	EA	823,900	206,000	300,000	133,000	1,462,900
TOTAL Virginia Key Section 111	1.00	EA	823,900	206,000	300,000	133,000	1,462,900

No errors detected...

* * * END OF ERROR REPORT * * *

Virginia Key Section 111
Option 5B
New Timber Groins (3)
Repair Existing Groin Field

Designed By: CESAJ
Estimated By: Anthony L. DiPiero, P.E.

Prepared By: Anthony L. DiPiero, P.E.

Preparation Date: 02/06/02
Effective Date of Pricing: 02/06/02
Est Construction Time: 300 Days

Sales Tax: 6.50%

Summary of the scope of Work provided by Tom Martin, EN-HC on 4 Apr 2001; then updated 4 Feb 2002.

Construct 3 new groins along the eastern end of the County Park and repair the damaged portions of 25 existing timber groins for a total of 790 lf (350' new groins + 440' repair of existing groins). All new groin construction will be land-based. Shallow offshore depths and the presence of extensive nearshore seagrass beds make water-based construction (barge, etc) impractical.

Due to the presence of these seagrass areas along the length of the project, turbidity containment devices will be used during any operations, which generate turbidity. Note that turbidity monitoring is incorporated into Field Overhead percentage for this phase of estimate.

The timber groins would be constructed using the timber groin design previously provided to EN-C. The quantities of materials are provided in table 11b of the report. CCA-treated lumber is to be used in place of the creosote-treated lumber specified in the report. The estimate includes the cost of mitigating 850 sq.ft of seagrass (500 sqft from kingpiles and 350 feet from groins). The issue of seagrass replanting was discussed with Mr. Mike Dupes. Based on information contained in a WES report from the late 1970's, the cost per square foot of plug was brought forward to today's dollars. Plug spacing is 0.5 sqft of plug on 18" centers.

Beach Fill Construction. A total of 8,050 cubic yards of beach fill will be placed along a 1,300-ft reach of eroded shoreline along the eastern portion of the County Park. Fill will be placed mechanically (not hydraulically) to minimize impacts to the adjacent seagrass areas. Upland borrow area is adjacent to fill area. Assume that this material will NOT need to be sieved (to remove rock) OR hydrocycloned (to remove silt) prior to placement on the beach. Considerable debris (downed trees, logs, stumps, etc.) will need to be removed from the project area prior to placement of beach fill and disposed of off-site. The cost estimate includes the cost of mitigating 7,440 sq. ft of seagrass due to placement of the beach fill. An additional component will be the construction of a 2' high dune along the landward edge of the beach fill along the eastern 1300' of park. The total volume is 710 cy.

Removal of Concrete King Piles. 26 concrete king piles will be removed from the central portion of the existing groin field and stockpiled on site.

Portions of 25 partially deteriorated timber groins along the western portion of the park will be removed (a total of 500 lf) and disposed on-site in a designated portion of the park.

Project Owner costs:
A contingency of 25% was applied to the total contract cost.
PE&D: $ 300,000 (Per email from Tom Martin 4/18/01)
S&I was set as 10%
Estimated time for construction past NTP is 10 months.
As of 4 Feb 2002, NTP is expected to be issued in July, 2002. No escalation has been applied due to the short duration between this estimate and midpoint of construction.

SUMMARY REPORTS SUMMARY PAGE

No Detailed Estimate...

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 3 (Rounded to 100's) **

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	16,000	5,200	57,600
01- A/10 Breakwaters and Seawalls	1.00	EA	346,000	86,500	190,800	62,300	685,600
01- A/17 Beach Replenishment	1.00	EA	169,100	42,300	93,200	30,500	335,000
TOTAL Construction Costs	1.00	EA	544,200	136,000	300,000	98,000	1,078,300
TOTAL Virginia Key Section 111	1.00	EA	544,200	136,000	300,000	98,000	1,078,300
TOTAL Virginia Key Section 111	1.00	EA	544,200	136,000	300,000	98,000	1,078,300

** PROJECT OWNER SUMMARY - Level 5 (Rounded to 100's) **

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work							
01- A/01.06 Mob, Demob & Preparatory Work							
01- A/01.06.01 Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	16,000	5,200	57,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	16,000	5,200	57,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	29,100	7,300	16,000	5,200	57,600
01- A/10 Breakwaters and Seawalls							
01- A/10.00 Breakwaters and Seawalls							
01- A/10.00.01 Remove Existing Groin Field	5.00	CLF	21,500	5,400	11,800	3,900	42,500
01- A/10.00.02 Conc. Pile Removal	26.00	EA	39,400	9,900	21,700	7,100	78,100
01- A/10.00.03 New/Rep Timber Groins (A-C/1-24)	7.90	CLF	270,700	67,700	149,200	48,800	536,400
01- A/10.00.04 Re-Plant Sea Grass	850.00	SF	14,400	3,600	8,000	2,600	28,600
TOTAL Breakwaters and Seawalls	1.00	EA	346,000	86,500	190,800	62,300	685,600
TOTAL Breakwaters and Seawalls	1.00	EA	346,000	86,500	190,800	62,300	685,600
01- A/17 Beach Replenishment							
01- A/17.00 Beach Replenishment							
01- A/17.00.20 Re-Plant Sea Grass	7440.00	SF	126,400	31,600	69,700	22,800	250,400
01- A/17.00.70 Place Beach Fill	8050.00	CY	30,600	7,700	16,900	5,500	60,600
01- A/17.00.75 Construct 2' high berm	710.00	CY	2,700	700	1,500	500	5,300
01- A/17.00.99 Debris Clearing & Disposal	1.00	EA	9,400	2,300	5,200	1,700	18,600
TOTAL Beach Replenishment	1.00	EA	169,100	42,300	93,200	30,500	335,000
TOTAL Beach Replenishment	1.00	EA	169,100	42,300	93,200	30,500	335,000
TOTAL Construction Costs	1.00	EA	544,200	136,000	300,000	98,000	1,078,300
TOTAL Virginia Key Section 111	1.00	EA	544,200	136,000	300,000	98,000	1,078,300
TOTAL Virginia Key Section 111	1.00	EA	544,200	136,000	300,000	98,000	1,078,300

No errors detected...

* * * END OF ERROR REPORT * * *

Virginia Key Section 111
Timber Groin Maintenance Only

Designed By: CESAJ
Estimated By: Anthony L. DiPiero, P.E.

Prepared By: Anthony L. DiPiero, P.E.

Preparation Date: 02/06/02
Effective Date of Pricing: 02/06/02
Est Construction Time: 120 Days

Sales Tax: 6.50%

Summary of the scope of Work provided by Tom Martin, EN-HC on 4 Apr 2001; then updated 4 Feb 2002.

Repair the damaged portions of 25 existing and 3 new timber groins for a total of 535 lf (440' existing + 95' new).
All groin construction will be land-based. Shallow offshore depths and the presence of extensive nearshore seagrass beds make water-based construction (barge, etc) impractical.

Due to the presence of these seagrass areas along the length of the project, turbidity containment devices will be used during any operations, which generate turbidity. Note that turbidity monitoring is incorporated into Field Overhead percentage for this phase of estimate.

The timber groins would be constructed using the timber groin design previously provided to EN-C. The quantities of materials are prorated from table 11b of the report. CCA-treated lumber is to be used in place of the creosote-treated lumber specified in the report.

Project Owner costs:
A contingency of 20% was applied to the total contract cost.
PE&D: $ 230,000 (Per email from Tom Martin 4/18/01)
S&I was set as 10%

Estimated time for construction past NTP is 4 months.

No Detailed Estimate...

No Backup Reports...

* * * END TABLE OF CONTENTS * * *

** PROJECT OWNER SUMMARY - Level 5 (Rounded to 100's) **

	QUANTITY	UOM	CONTRACT	CONTING	PE&D	S&I	TOTAL COST
01 Virginia Key Section 111							
01- A Construction Costs							
01- A/01 Mob, Demob & Preparatory Work							
01- A/01.03 Mob, Demob & Preparatory Work							
01- A/01.03.01 Mob, Demob & Preparatory Work	1.00	EA	8,300	1,700	7,900	1,800	19,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	8,300	1,700	7,900	1,800	19,600
TOTAL Mob, Demob & Preparatory Work	1.00	EA	8,300	1,700	7,900	1,800	19,600
01- A/10 Breakwaters and Seawalls							
01- A/10.00 Breakwaters and Seawalls							
01- A/10.00.01 Remove Existing Groin Field	5.35	CLF	49,000	9,800	46,900	10,600	116,300
01- A/10.00.02 Replace Timber Groin Field	5.35	CLF	183,300	36,700	175,200	39,500	434,700
TOTAL Breakwaters and Seawalls	1.00	EA	232,400	46,500	222,100	50,100	551,000
TOTAL Breakwaters and Seawalls	1.00	EA	232,400	46,500	222,100	50,100	551,000
TOTAL Construction Costs	1.00	EA	240,600	48,100	230,000	51,900	570,700
TOTAL Virginia Key Section 111	1.00	EA	240,600	48,100	230,000	51,900	570,700
TOTAL Virginia Key Section 111	1.00	EA	240,600	48,100	230,000	51,900	570,700

No errors detected...

* * * END OF ERROR REPORT * * *

SUB-APPENDIX A-2

GEOTECHNICAL ANALYSIS

GEOTECHNICAL INVESTIGATIONS

General.
Virginia Key is a barrier island located along Eastern Biscayne Bay and north of Key Biscayne on the Atlantic coast of Dade County, Florida. The project area is located along the southern shoreline of the public park on the southeast side of Virginia Key. The park's shoreline consists of two separate regions; a relic groin field lies along the southwestern shoreline of the park and an existing rubble-mound groin field along the northeastern shoreline of the park. Between these two regions is a 1,300 ft. gap, whose shoreline shows signs of moderate to severe erosion with a 1 to 2 foot vertical scarp. The shoreline along the southwestern timber groin field is in generally good condition, with a sandy beach 30 to 40 ft. wide at low tide. It is proposed to install new timber pile groins along the eroded gap and the southwestern relict groin field region and provide sand for beach renourishment above Mean Lower Low Water.

Investigations Performed.
Three initial groin foundation borings (CB-VK01-1 through 3) were drilled in January of 2001 and all subsequent sampling performed in October of the same year. As the project plan formed, four additional groin foundation borings (CB-VK01-7 through 10) were drilled, in addition to eight test pits to characterize the two sand mounds and five beach sample profile lines to determine the native beach conditions. Test pits were also sampled (TP-VKDA1&2) in the disposal area on the north end of Virginia Key to decide if the material could be processed for use as beach nourishment material. In addition to the Section 111 Study exploration, further sampling was performed around Virginia Key to characterize elements of the Section 1135, ecosystem restoration study. All boring, test pit and surface sample locations are shown on figure 1. Core boring logs and laboratory test results follow the figures.

Materials Encountered.
Groin Foundation. The ocean shoreline of Virginia Key is composed of a medium dense, poorly graded quartz and carbonate sand to elevations of -13 to – 16 MLLW, overlying medium hard, fossiliferous, oolitic limestone. Five hundred feet inland from the coast, at a proposed freshwater pond area, the surficial sand averaged 57 percent visual shell content and 12 percent silt. The easternmost core boring (CB-VK01-1) encountered a 1 ft. layer of peat at elevation +1.3 MLLW and a 1-ft. layer of clay at elevation -3.6 MLLW. During a field inspection December 2000, the exposed scarp in the vicinity of this easternmost core boring found exposed layers of peat and gray (CL) clay 1 to 2 ft. high along the beach. Timber piles can be driven to the proposed tip elevation of – 16 MLLW. Driving shoes will be required.

Project Beach Sand. Two surface beach sample profile lines (P/L-VK01-4&5) were taken on the western portion of Virginia Key's ocean beach. In general the beach is fine quartz sand with an average of 26 percent visual shell content. The composite mean grain size is 0.47 mm (1.12 phi) with a sorting value of 1.31, as compared on table 1. This mean grain size is quite coarse, compared to the design composite mean grain size for

Miami Beach, of 0.34mm. Comparison composite gradation curves are shown on figure 2 and frequency distribution curves shown on figure 3. For the most part, the sand found on the western beach area is sand that has drifted along the beach fed from the eastern beach area. The groin field was filled with sand from dredging of Miami Harbor in the 1970's. Onshore-offshore sand movement is limited due to extensive grass beds existing to the low tide line.

Eastern Beach Sand. Three surface beach sample profile lines (P/L-VK01-1 through 3) were taken between the four western most rock groins on the eastern ocean shoreline (P/L-VK01-1 and 2 are north and off the edge of figure 1). This park area with the rock groin field was filled with Miami Harbor dredged material in the 1970's. This material contained much rock and coarse shell fragments that still remain distributed within the beach sand and is obvious on the surface of the beach. The composite mean grain size is 0.53 mm (0.92 phi) with a sorting value of 1.99, as compared on table 1. Comparison composite gradation curves are shown on figure 2 and frequency distribution curves shown on figure 3.

Sand Mounds. The two sand mounds located just behind the ocean beach are stockpiles of material excavated from Key Biscayne. The sand was stored on Virginia Key for the potential use as beach nourishment material. The sand mounds were surveyed and sampled by Dade County Department of Environmental Resources Management (DERM) reported in a memo dated April 2001. The reported approximate volume of sand contained in sand mound 1 (southwest) is 12,000 cubic yards and 60,000 cubic yards in sand mound 2 (northeast). The composite mean grain size and sorting for the two sand mounds are shown on table 1. The composite gradation curves and frequency curves are shown on Fig. 2 and 3. Sand Mounds 1&2 on table 1 and figure 2 are simply the averaged values for the two individual composite curves for Sand Mound 1 and Sand Mound 2.

Table 1.
Virginia Key Sediment Statistics

Composite	Mean Grain Size		Sorting	Adj. SPM	% Passing	% Passing	Visual Shell	Total Carbonate
	mm	phi	phi		200 Sieve	230 Sieve		(Acid Insoluble)
Sand Mound 1	0.29	1.96	1.31	2.27	8.7	7.6	55.8	53
Sand Mound 2	0.34	1.71	1.52	1.68	8.7	7.2	34.0	64
Sand Mounds 1&2	0.31	1.84	1.43	-	8.7	7.5	44.9	-
Area 5-Western Beach	0.47	1.12	1.15	-	1.6	1.4	25.9	not available
Area 9 Eastern Beach	0.53	0.92	1.99	-	0.8	0.8	20.4	not available

As can be seen from table 1 and figures 2 and 3, the sand mounds are slightly finer grained than the existing beach sand. Coarse sand on Florida beaches typically occurs from whole and broken shell fragments contributed from offshore deposits or living and dying organisms. The sediment contribution from these sources continues after a beach renourishment, so the new beach sand accumulates the whole and broken shell, shifting to a mean grain size closer matching that of the original sand. In this case, the coarse sand is from the dredged material feeder beach to the east.

The silt content of the sand mounds average eight percent. This is below the State of Florida, Department of Environmental Regulation guideline of less than 10 percent passing the 230 sieve. The visual percent shell of 55.8 and 34.0 percent indicates the sand is composed of roughly 50 to 70 percent carbonate with the remainder being quartz. The acid insoluble test of the Sand Mounds verify this, with results indicating 50 to 60 percent carbonate with the remainder being quartz. With the project beach registering 25.9 percent visual shell, the sand mounds are a good match to the existing beach quartz-carbonate sand composition.

The comparison between the grain size and sorting of the existing beach and the potential sand source using the Adjusted SPM (R_a) method indicates an overfill ratio for the Sand Mounds of 2.27 and 1.68. These are surprisingly high overfill ratios for the size and quality of the Sand Mound sand, but the project beach is surprisingly coarse in the medium to fine sand sizes, undoubtedly due to the extremely coarse nature of the feeder beach to the east. The Adjusted SPM overfill ratio is a tool to predict the sorting characteristics of the new beach sand and volumetric requirements. The plan of the proposed beach nourishment of placement of sand above MLLW, only, diminishes the predictive nature of this tool, since the placed sand is not intended to be sorted by the sea. The results do highlight the coarser nature of Sand Mound 2. For comparison purposes, the sediment statistics for Sand Mounds 1&2 (separately) were compared to the design sediment statistics for the Miami Beach project. The design mean grain size for Miami Beach is 0.34 mm and sorting of 1.04. Using these values in the Adjusted SPM, the overfill ratio is 1.23 and 1.18 for Sand Mound 1 and 2, respectively. These show the roughly 1.2 overfill ratio that would be used for Miami Beach and the Sand Mounds as a sand source.

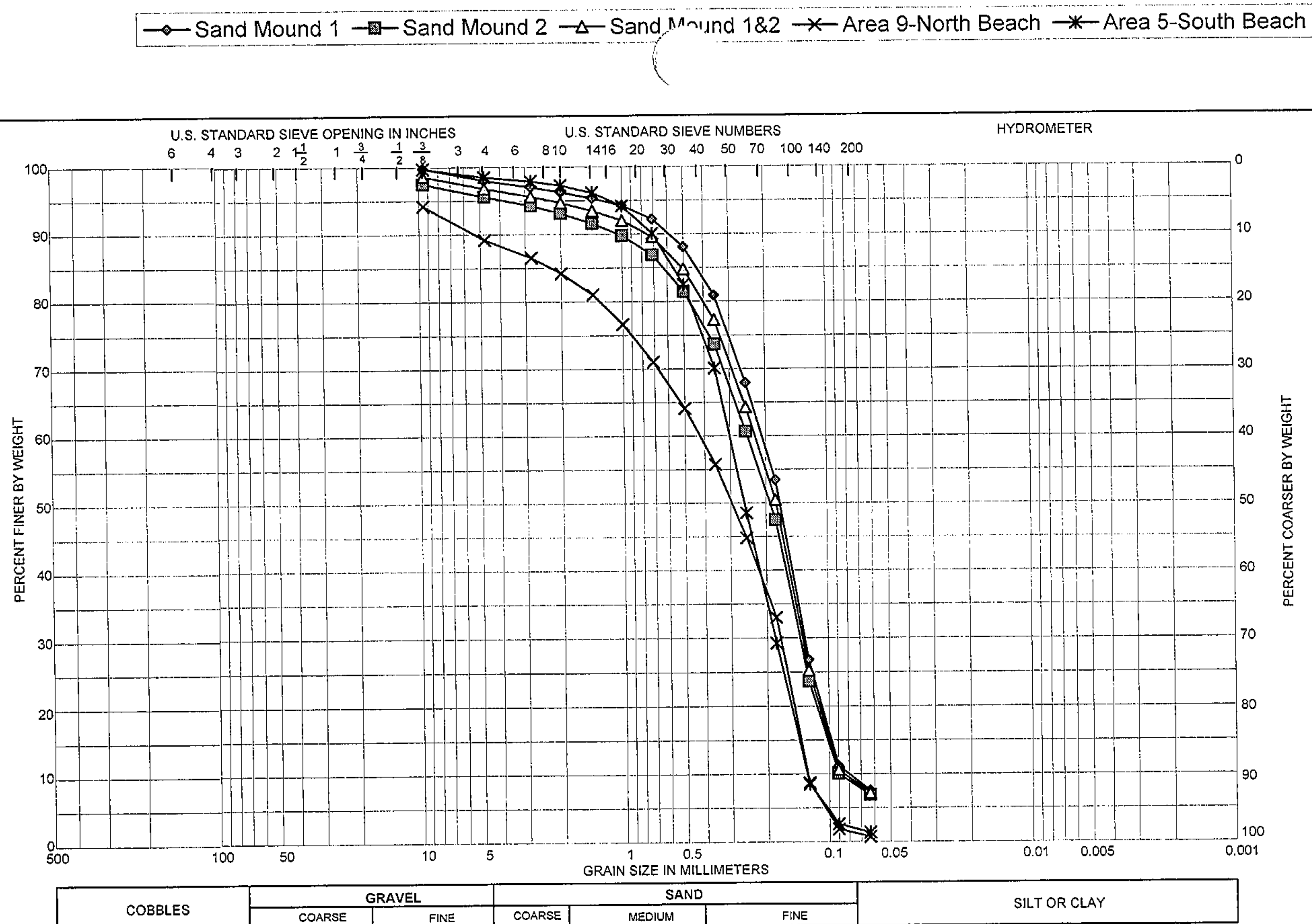
Disposal Area. This disposal area was used for disposal of materials dredged from Miami Harbor. It contains dredged rock, sand and silt. Separate areas of the disposal area were used to separate different materials as effectively as possible, but sand and rock generally occur together. Test pit samples were taken to evaluate the materials potential to be processed and used as beach nourishment fill. The dredged limestone and sandy materials are described as 84 percent carbonate (limestone) and 16 percent quartz sand. Of the entire sample, 20 percent is visual shell. The bulk samples of sand and rock were screened over the ½ inch sieve to remove the coarser gravel fraction and provide a look at a possible sand product. The raw sample gradation and the ½ inch sieve screening gradation curves are included in the laboratory test results. This material is essentially crushed limestone sand, similar to manufactured sand produced at the sand and gravel plants in Miami. There is 16 percent fraction of quartz sand in the disposal area sand. Manufactured sand is excellent for construction material, but tends to compact when placed on the beach. The dredged limestone sand and rock in the disposal area will most likely have the same characteristics and is not recommended for beach placement. This is due to the angular grains making up the sand and processing to remove silt and provide a favorable gradation will not change this characteristic.

Summary and Conclusions.

The foundation condition for the timber pile groin field consists of sand to elevation -13 to -16 MLLW, over medium hard limestone. The shallow defects of clay and peat layers, noted above, should not detract from the construction or stability of the timber pile groins.

The sand mounds can supply sand for beach nourishment. The sand is approximately 50 percent quartz/carbonate in composition. Sand Mound 2 has a coarser mean grain size and better matches the sand on the beach. Both sand mounds can be used for construction and fill material around the park.

Although the material in the disposal area can be processed to produce a favorable gradation for use on the beach, the angular nature of the grains will cause it to compact. The material in the disposal area can be used for construction materials, but is not recommended for use on the beach.



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
Sand Mound 1		(SP-SM)				
Sand Mound 2		(SP-SM)				
Sand Mound 1&2		~~(SP-SM)~~				
~~North Beach~~		~~(SP)~~				
South Beach		(SP)				

Project VIRGINIA KEY
Section 111 Study

Area

Boring No. Composite Curves

Date 12/19/01

GRADATION CURVES

ENG FORM 1 MAY 63 2087

Figure 2

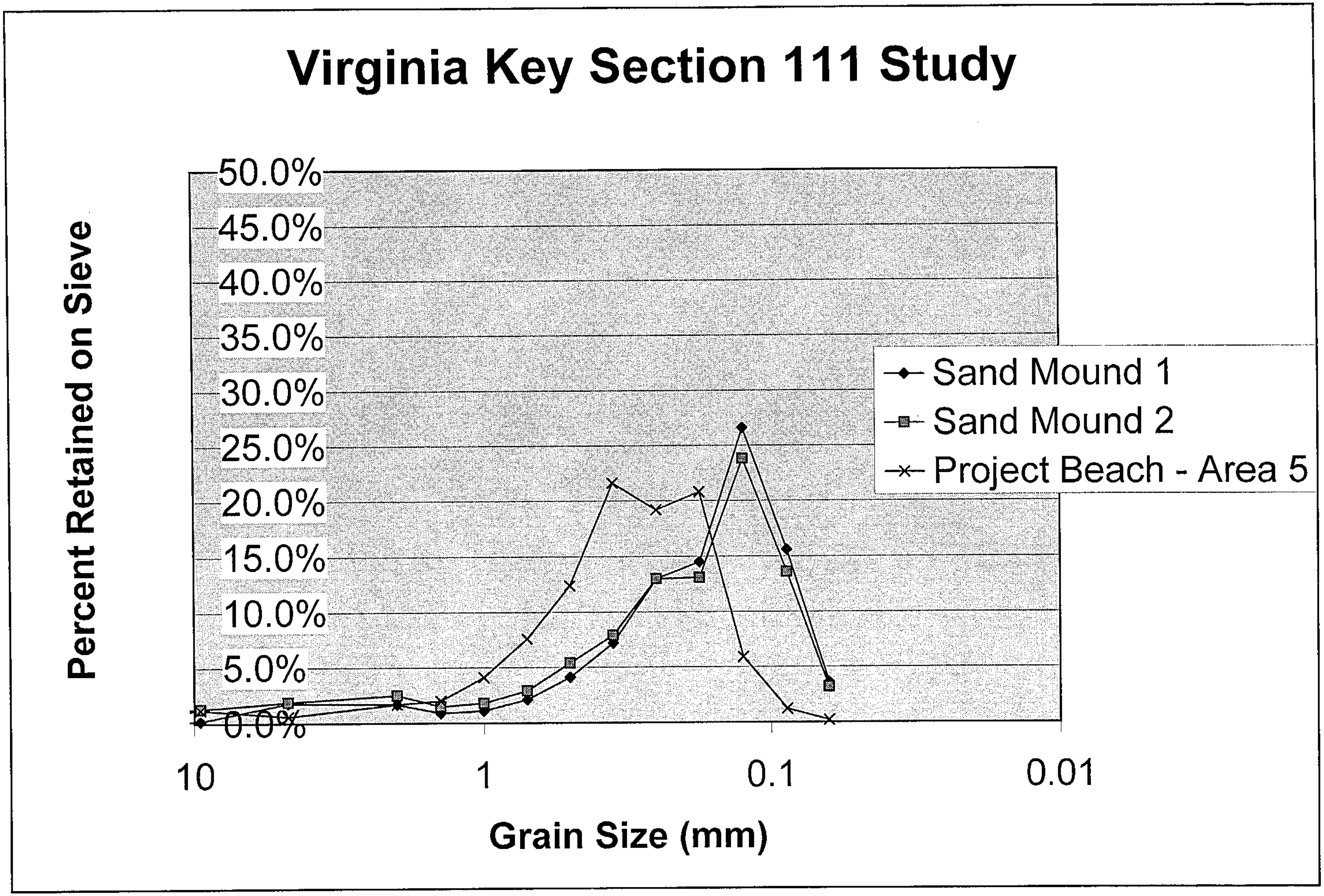

Virginia Key Section 111 Study
50.0%
45.0%
40.0%
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Percent Retained on Sieve
10
1
0.1
0.01
Grain Size (mm)
Sand Mound 1
Sand Mound 2
Project Beach - Area 5

Figure 3

Hole No.CB-VK01-1

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District — SHEET 1 OF 2
1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=779,379 Y=511,185	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW; Horizontal Datum: FLE NAD27 US Ft
3. DRILLING AGENCY: Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 45
4. HOLE NO. (As shown on drawing title and file number): CB-VK01-1	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 16 undisturbed: 0
5. NAME OF DRILLER: L. WOOTERS	14. TOTAL NUMBER OF CORE BOXES: 2
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER: 1.3 ft.
7. THICKNESS OF BURDEN: 0 Ft.	16. DATE HOLE: STARTED 01/30/01 COMPLETED 01/30/01
8. DEPTH DRILLED INTO ROCK: 0 Ft.	17. ELEVATION TOP OF HOLE: 4.8 Ft.
9. TOTAL DEPTH OF HOLE: 27.5 Ft.	18. TOTAL CORE RECOVERY FOR BORING: 68 %
	19. SIGNATURE OF GEOLOGIST: S. MYERS

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/ .5'
4.8	0.0					4.8	
			SAND, poorly-graded, mostly fine to medium grained quartz and carbonate, trace of wood, dry, tan (SP)	20	1	SPT 3.3	1, 2, 4
			At 2.3', Little shell framents up to 1/4", moist, gray	40	2	SPT 1.8	4, 7, 4
1.3	3.5		PEAT, trace quartz sand, wet, fibrous, brown (PT)	93	3	SPT .3	4, 5, 7
.3	4.5		SAND, poorly-graded, mostly fine to medium grained carbonate and quartz, some shell fragments <2mm, wet, gray (SP)	80	4	SPT -1.2	5, 8, 10
				33	5	SPT -2.7	3, 2, 3
-3.6	8.4		CLAY, fat, medium plasticity, some silt, calcareous, moist, light grey (CH)	87	6	SPT -4.2	2, 1, 10
-4.2	9.0		SAND, poorly-graded, fine to medium grained, some shells, calcareous, wet (SP)	40	7	SPT -5.7	1, 1, WOH
-6.6	11.4		SILT, inorganic-H, calcareous, wet, imbedded silt and very fine sand, light grey (MH)	100	8	SPT -7.2	1, 2, 1
-8.2	13.0			67	9	SPT -8.7	3, 4, 6
			SAND, poorly-graded, mostly fine to coarse grained quartz, some round to subangular shell fragments, weak reaction to HCl, black and white (SP)	100	10	SPT -10.2	12, 17, 50
				100	11	SPT -11.7	12, 15, 34
				100	12	SPT -13.2	5, 12, 23
-14.7	19.5			100	13	SPT -14.7	7, 15, 23
			LIMESTONE, fine grained, massive, vuggy, poorly cemented, few mostly graded oolites and shell fragments	67	14	SPT -16.2	13, 17, 13
				93	15	SPT -17.7	12, 15, 28
						(continued)	

Depth scale: 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5

Hole No.CB-VK01-1

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE: 4.8 Ft.

SHEET 2 OF 2

PROJECT: Virginia Key

INSTALLATION: Jacksonville District

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/.5'
-17.7	22.5					-17.7	
				36	16	NX Diamond Bit D.T. = 7 min	
-22.7	27.5					-22.7	
			Note: 1. Soils are visually classified in accordance with the Unified Soils Classification System. 2. Elevation determined from temporary tide staffs set to high tide on 1/29/01 at 2.24 ft above MLLW at Virginia Key tide guage. Tide guage located on Miami University School of Marine Science, 1/4 mile south of the project site. 3. Sand Pile Sample #1: Location: 303' N83W of CB-VK01-1 on vertical open face of pile. Photo taken. Dug into face 12". No sample collected, <100% passing 3/4". Description: SAND, poorly-graded, mostly fine grained carbonate, few shells and shell fragments up to 1 3/8", trace quartz, trace silt, strong reaction with HCl, moist, tan (SP) 4. Sand Pile Sample #2: Location: 510' S69W of CB-VK01-1 on open face of pile 45' from beach. Photo taken. Dug into face 12" for sample. No sample collected because shells exceeded 3/4" in diameter. Description: SAND, poorly-graded, mostly fine to medium grained angular to subrounded carbonate and quartz, few shells 1/4" to 1 1/2", trace silt, moist, tan (SP)			140# hammer w/30" drop used with 2.0' split spoon (1 3/8" I.D. X 2" O.D.).	

Depth scale: 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5, 45, 47.5, 50

Hole No.CB-VK01-2

DRILLING LOG

DIVISION: South Atlantic	INSTALLATION: Jacksonville District — SHEET 1 OF 2
1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=778,669 Y=510,636	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW; Horizontal Datum: FLE NAD27 US Ft
3. DRILLING AGENCY: Corps of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME 45
4. HOLE NO. (As shown on drawing title and file number): CB-VK01-2	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
5. NAME OF DRILLER: L. WOOTERS	14. TOTAL NUMBER OF CORE BOXES: 2
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER
	16. DATE HOLE: STARTED 01/31/01 COMPLETED 01/31/01
7. THICKNESS OF BURDEN: 0 Ft.	17. ELEVATION TOP OF HOLE: 5.1 Ft.
8. DEPTH DRILLED INTO ROCK: 0 Ft.	18. TOTAL CORE RECOVERY FOR BORING: 64 %
9. TOTAL DEPTH OF HOLE: 25.0 Ft.	19. SIGNATURE OF GEOLOGIST: S. MYERS

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/.5'
5.1	0.0		SAND, poorly-graded, mostly fine to medium grained quartz and carbonate, trace angular to subrounded shell fragments, strong reaction to HCl, moist, tan (SP)	67	1	5.1 SPT 3.6	1, 1, 4
				67	2	SPT 2.1	3, 6, 7
			At 2.1', trace silt, wet, grading to gray; At 1.6', gray	80	3	SPT .6	4, 7, 8
				87	4	SPT -.9	5, 9, 13
				67	5	SPT -2.4	6, 10, 13
				47	6	SPT -3.9	6, 7, 9
			At -3.9', little silt	80	7	SPT -5.4	4, 6, 9
				87	8	SPT -6.9	5, 7, 9
			At -7.2, 1/2" shell layer	60	9	SPT -8.4	5, 8, 35
-8.9	14.0		SAND, mostly fine grained angular to rounded carbonate and quartz, few silt, strong reaction to HCl, wet, grey (SP)	60	10	SPT -9.9	34, 36, 22
				53	11	SPT -11.4	13, 22, 50
				67	12	SPT -12.9	17, 35, 53
-12.7	17.8		LIMESTONE, soft, weathered, fine grained, vuggy, poorly cemented, oolitic, tan	47	13	SPT -14.4	15, 23, 78
			At -14.4', cementation increasing and less clay pore filling	27	14	SPT -15.9	12, 19, 23
				80	15	SPT -17.4	12, 16, 15
						(continued)	

Depth scale: 0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5

Hole No.CB-VK01-2

DRILLING LOG (Cont. Sheet)	ELEVATION TOP OF HOLE 5.1 Ft.	SHEET 2 OF 2
PROJECT Virginia Key	INSTALLATION Jacksonville District	

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/.5'
-17.4	22.5					-17.4	
				47	16	SPT	10 18 22
						-18.9	
				47	17	SPT	14 12
-19.9	25.0					-19.9	
			Note: 1. Soils are visually classified in accordance with the Unified Soils Classification System.			140# hammer w/30" drop used with 2.0' split spoon (1 3/8" I.D. X 2" O.D.).	

Depth scale: 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5, 45, 47.5, 50

Hole No.CB-VK01-3

DRILLING LOG

- DIVISION: South Atlantic
- INSTALLATION: Jacksonville District
- SHEET 1 OF 2
- 1. PROJECT: Virginia Key
- 2. LOCATION (Coordinates or Station): X=777,740 Y=510,105
- 3. DRILLING AGENCY: Corps of Engineers
- 4. HOLE NO. (As shown on drawing title and file number): CB-VK01-3
- 5. NAME OF DRILLER: L. WOOTERS
- 6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
- 7. THICKNESS OF BURDEN: 0 Ft.
- 8. DEPTH DRILLED INTO ROCK: 0 Ft.
- 9. TOTAL DEPTH OF HOLE: 25.0 Ft.
- 10. SIZE AND TYPE OF BIT: See Remarks
- 11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLLW; Horizontal Datum: FLE NAD27 US Ft
- 12. MANUFACTURER'S DESIGNATION OF DRILL: CME 45
- 13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
- 14. TOTAL NUMBER OF CORE BOXES: 2
- 15. ELEVATION GROUND WATER: −0.8 ft.
- 16. DATE HOLE: STARTED 01/31/01 COMPLETED 01/31/01
- 17. ELEVATION TOP OF HOLE: 3.8 Ft.
- 18. TOTAL CORE RECOVERY FOR BORING: 72 %
- 19. SIGNATURE OF GEOLOGIST: S. MYERS

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/.5'
3.8	0.0					3.8	
			SAND, poorly-graded, fine to medium grained subangular quartz and carbonate, strong reaction to HCl, moist, tan (SP)	67	1	SPT 2.3	1 / 1 / 4
				53	2	SPT .8	3 / 6 / 7
			At −3.8', fine to coarse grained, some shell fragments	87	3	SPT −.7	4 / 7 / 8
			At 5.4', gray and wet At 6.3', trace silt	100	4	SPT −2.2	5 / 9 / 13
				53	5	SPT −3.7	6 / 10 / 13
				67	6	SPT −5.2	6 / 7 / 9
				67	7	SPT −6.7	4 / 6 / 9
				67	8	SPT −8.2	5 / 9 / 7
			At 14.1', well-graded layer, fine grained	73	9	SPT −9.7	5 / 8 / 35
				53	10	SPT −11.2	24 / 36 / 22
				53	11	SPT −12.7	19 / 22 / 50
				60	12	SPT −14.2	17 / 35 / 53
−15.7	19.5			67	13	SPT −15.7	15 / 23 / 78
			SAND, silty, low plasticity, mostly fine grained carbonate and quartz, little clay, trace large shells, wet, gray (SM)	100	14	SPT −17.2	12 / 19 / 23
−18.2	22.0			87	15	SPT −18.7	12 / 16 / 15
			LIMESTONE, soft, fine to medium				
						(continued)	

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PROJECT: Virginia Key

HOLE NUMBER: CB-VK01-3

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE	SHEET 2 OF 2
3.8 Ft.	

PROJECT	INSTALLATION
Virginia Key	Jacksonville District

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit & Barrel	BLOWS/.5'
-18.7	22.5					-18.7	
			grained, vuggy, fossiliferous, oolitic, weakly cemented, tan	67	16	SPT -20.2	10 18 22
-21.2	25.0			100	17	SPT -21.2	14 12

Notes:

1. Soils are visually classified in accordance with the Unified Soils Classification System.

2. Location approximately 5 ft west of high tide mark.

140# hammer w/30" drop used with 2.0' split spoon (1 3/8" I.D. X 2" O.D.).

Depth scale: 22.5, 25, 27.5, 30, 32.5, 35, 37.5, 40, 42.5, 45, 47.5, 50

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT	HOLE NUMBER
Virginia Key	CB-VK01-3

Boring Designation CB-VK01-4

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION COORDINATES: X = 778,258 Y = 511,310	11. COORDINATE SYSTEM/DATUM: State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
3. DRILLING AGENCY: Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. BORING DESIGNATION: CB-VK01-4	13. TOTAL SAMPLES: DISTURBED 7; UNDISTURBED (UD) 0
5. NAME OF DRILLER: L. Wooters	14. TOTAL NUMBER CORE BOXES: 1
6. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:	15. ELEVATION GROUND WATER: 0.7 Ft.
7. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. DATE BORING: STARTED 10-16-01; COMPLETED 10-16-01
8. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. ELEVATION TOP OF BORING: 4.9 Ft.
9. TOTAL DEPTH OF BORING: 10.5 Ft.	18. TOTAL RECOVERY FOR BORING: 48 %
	19. SIGNATURE AND TITLE OF INSPECTOR: S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
4.9	0.0		SAND, silty, mostly fine to medium-grained shell, little silt, trace fine-grained quartz, moist, tan (SM)	53	1		4.9 SPT Sampler 3.4	2, 6, 8	14
				40	2		SPT Sampler 1.9	5, 7, 8	15
			At El. 1.4 Ft., wet	0	3		SPT Sampler 0.4	7, 5, 5	10
				53	4 D-4		SPT Sampler -1.1	5, 4, 3	7
-0.9	5.8		PEAT, some sand, moist, brown (PT)	0	5		SPT Sampler -2.6	1, 1, 1	2
-2.6	7.5		SAND, silty, mostly angular fine to coarse-grained shell, little silt, wet, tan (SM)	100	6 D-6		SPT Sampler -4.1	4, 10, 11	21
-3.6	8.5		SAND, silty, mostly quartz, gray (SM)	87	7		SPT Sampler -5.6	7, 12, 13	25
-5.6	10.5								

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).

DRAFT

ENG FORM 1836
NOV 01

Boring Designation CB-VK01-5

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION COORDINATES: X = 778,644 Y = 511,510	11. COORDINATE SYSTEM/DATUM: State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
3. DRILLING AGENCY: Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. BORING DESIGNATION: CB-VK01-5	13. TOTAL SAMPLES: DISTURBED 7; UNDISTURBED (UD) 0
5. NAME OF DRILLER: D. Hewett	14. TOTAL NUMBER CORE BOXES: 1
6. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:	15. ELEVATION GROUND WATER: 2.1 Ft.
7. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. DATE BORING: STARTED 10-11-01; COMPLETED 10-11-01
8. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. ELEVATION TOP OF BORING: 5.6 Ft.
9. TOTAL DEPTH OF BORING: 10.5 Ft.	18. TOTAL RECOVERY FOR BORING: 62 %
	19. SIGNATURE AND TITLE OF INSPECTOR: S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
5.6	0.0						5.6		
			SAND, poorly-graded, mostly fine to medium-grained quartz, little shell, trace fine-grained gravel, trace plant debris, strong reaction with HCl, moist, tan (SP)	40	1		SPT Sampler 4.1	2, 6, 8	14
			At El. 4.1 Ft., little fine gravel-sized gravel, strong reaction with HCl	53	2		SPT Sampler 2.6	4, 9, 12	21
3.1	2.5		SAND, silty, mostly fine to medium-grained shell, little silt, little fine-grained quartz, few fine to coarse-grained gravel, trace rounded shell, strong reaction with HCl, wet, tan (SM) At El. 2.6 Ft., no gravel, becoming gray	40	3		SPT Sampler 1.1	4, 2, 6	8
				67	4		SPT Sampler -0.4	4, 2, 8	10
				93	5		SPT Sampler -1.9	4, 5, 11	16
				67	6		SPT Sampler -3.4	6, 7, 10	17
-4.9	10.5			73	7		SPT Sampler -4.9	6, 8, 10	18

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

2. Samples described from jars.

140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).

0 5 10 15

DRAFT

ENG FORM 1836
NOV 01

Boring Designation CB-VK01-6

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 1 SHEETS

1. PROJECT	Virginia Key
2. LOCATION COORDINATES	X = 779,230 Y = 511,537
3. DRILLING AGENCY	Corps Of Engineers
4. BORING DESIGNATION	CB-VK01-6
5. NAME OF DRILLER	D. Hewett
6. DIRECTION OF BORING	☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:
7. THICKNESS OF OVERBURDEN	0.0 Ft.
8. DEPTH DRILLED INTO ROCK	0.0 Ft.
9. TOTAL DEPTH OF BORING	10.5 Ft.
10. SIZE AND TYPE OF BIT	See Remarks
11. COORDINATE SYSTEM/DATUM	State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
12. MANUFACTURER'S DESIGNATION OF DRILL	CME-45
13. TOTAL SAMPLES	DISTURBED: 7; UNDISTURBED (UD): 0
14. TOTAL NUMBER CORE BOXES	1
15. ELEVATION GROUND WATER	3.0 Ft.
16. DATE BORING	STARTED: 10-11-01; COMPLETED: 10-11-01
17. ELEVATION TOP OF BORING	5.3 Ft.
18. TOTAL RECOVERY FOR BORING	46 %
19. SIGNATURE AND TITLE OF INSPECTOR	S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
5.3	0.0		SAND, silty, mostly fine to coarse-grained shell, little fine-grained quartz, little silt, trace gravel, strong reaction with HCl, moist, tan (SM)	40	1		5.3 SPT Sampler 3.8	2, 8, 11	19
			From El. 3.8 to -5.2 Ft., no gravel.	40	2		SPT Sampler 2.3	3, 8, 8	16
			At El. 2.3 Ft., trace angular coarse-grained shell	20	3		SPT Sampler 0.8	2, 1, 1	2
			At El. -0.4 Ft., some silt, gray	20	4		SPT Sampler -0.7	2, 1, 1	2
			At El. -1.7 Ft., trace plant debris	93	5		SPT Sampler -2.2	4, 3, 5	8
			From El. -2.7 to -2.9 Ft., few clay, thin clay beds alternating with silty sand	67	6		SPT Sampler -3.7	7, 8, 10	18
-5.2	10.5			40	7		SPT Sampler -5.2	8, 7, 10	17

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

2. Samples logged from jars.

140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).

DRAFT

ENG FORM 1836
NOV 01

Boring Designation CB-VK01-7

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION COORDINATES: X = 779,441 Y = 511,218	11. COORDINATE SYSTEM/DATUM: State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
3. DRILLING AGENCY: Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. BORING DESIGNATION: CB-VK01-7	13. TOTAL SAMPLES: DISTURBED 17; UNDISTURBED (UD) 0
5. NAME OF DRILLER: L. Wooters	14. TOTAL NUMBER CORE BOXES: 2
6. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:	15. ELEVATION GROUND WATER: 0.5 Ft.
7. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. DATE BORING: STARTED 10-16-01; COMPLETED 10-16-01
8. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. ELEVATION TOP OF BORING: 2.0 Ft.
9. TOTAL DEPTH OF BORING: 25.5 Ft.	18. TOTAL RECOVERY FOR BORING: 72 %
	19. SIGNATURE AND TITLE OF INSPECTOR: S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
2.0	0.0		SAND, silty, mostly fine to coarse-grained shell, some angular to subrounded quartz, little silt (SM)	3	1		2.0 SPT Sampler 0.5	WOH, WOH, WOH	0
			At El. 0.5 Ft., wet	40	2		SPT Sampler -1.0	WOH, 1, 1	2
			From El. -2.0 to -2.2 Ft., lens	100	3 D-3		SPT Sampler -2.5	1, 3, 6	9
-2.5	4.5		SAND, clayey, mostly angular to subrounded fine to medium-grained shell, some silt, few clay, wet, gray (SC)	40	4		SPT Sampler -4.0	2, 2, 2	4
-4.0	6.0		SAND, poorly-graded, mostly fine to coarse-grained quartz, some subangular to rounded shell, trace silt, wet, gray (SP)	100	5 D-5		SPT Sampler -5.5	2, 3, 5	8
				73	6		SPT Sampler -7.0	7, 9, 11	20
				100	7		SPT Sampler -8.5	12, 21, 32	53
				100	8		SPT Sampler -10.0	18, 23, 33	56
				87	9 D-9		SPT Sampler -11.5	4, 9, 15	24
				93	10		SPT Sampler -13.0	4, 18, 22	40

0 5 10 15

DRAFT

(Continued)

ENG FORM 1836
NOV 01

Boring Designation CB-VK01-7

DRILLING LOG (Cont. Sheet)

INSTALLATION	SHEET 2 OF 2 SHEETS
Jacksonville District	

PROJECT	COORDINATE SYSTEM/DATUM	HORIZONTAL	VERTICAL
Virginia Key	State Plane, FLE	NAD27	NGVD29

LOCATION COORDINATES	ELEVATION TOP OF BORING
X = 779,441 Y = 511,218	2.0 Ft.

ELEV.	DEPTH	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			73	11		SPT Sampler -14.5	8 18 27	45
			53	12		SPT Sampler -16.0	9 14 20	34
-17.5	19.5		80	13		SPT Sampler -17.5	5 18 25	43
		SAND, silty, mostly fine to medium-grained quartz, some angular to rounded shell, little silt, strong reaction with HCl, wet, gray (SM)	60	14		SPT Sampler -19.0	4 13 28	41
			100	15 D-15		SPT Sampler -20.5	17 40 45	85
			53	16		SPT Sampler -22.0	10 27 34	61
-23.5	25.5		67	17		SPT Sampler -23.5	5 16 31	47

NOTES:

1. Soils are field visually classified in accordance with the Unified Soils Classification System.

140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).

Abbreviations:

WOH = Weight of Hammer.

Boring Designation CB-VK01-8

DRILLING LOG	DIVISION South Atlantic	INSTALLATION Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT Virginia Key	10. SIZE AND TYPE OF BIT See Remarks
2. LOCATION COORDINATES X = 779,156 Y = 511,086	11. COORDINATE SYSTEM/DATUM State Plane, FLE; HORIZONTAL NAD27; VERTICAL NGVD29
3. DRILLING AGENCY Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL CME-45
4. BORING DESIGNATION CB-VK01-8	13. TOTAL SAMPLES DISTURBED 17; UNDISTURBED (UD) 0
5. NAME OF DRILLER L. Wooters	14. TOTAL NUMBER CORE BOXES 1
6. DIRECTION OF BORING ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. ELEVATION GROUND WATER 0.8 Ft.
7. THICKNESS OF OVERBURDEN 0.0 Ft.	16. DATE BORING STARTED 10-17-01; COMPLETED 10-17-01
8. DEPTH DRILLED INTO ROCK 0.0 Ft.	17. ELEVATION TOP OF BORING 5.5 Ft.
9. TOTAL DEPTH OF BORING 25.5 Ft.	18. TOTAL RECOVERY FOR BORING 69 %
	19. SIGNATURE AND TITLE OF INSPECTOR S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
5.5	0.0		SAND, silty, mostly fine to medium-grained shell, little silt, trace angular to subrounded quartz, trace fine-grained gravel, strong reaction with HCl, dry, tan (SM)	40	1		5.5 SPT Sampler 4.0	2, 4, 7	11
				47	2		SPT Sampler 2.5	3, 5, 6	11
				67	3		SPT Sampler 1.0	4, 7, 9	16
			At El. 1.0 Ft., little quartz, few silt, gray At El. 0.8 Ft., wet	60	4		SPT Sampler -0.5	3, 5, 7	12
				100	5		SPT Sampler -2.0	5, 10, 15	25
				40	6		SPT Sampler -3.5	3, 5, 8	13
			At El. -3.5 Ft., trace wood debris	73	7		SPT Sampler -5.0	3, 7, 12	19
				73	8		SPT Sampler -6.5	8, 11, 6	17
			At El. -6.5 Ft., trace wood debris At El. -7.5 Ft., trace wood debris	67	9		SPT Sampler -8.0	7, 18, 11	29
				80	10		SPT Sampler -9.5	5, 14, 16	30

Depth scale: 0, 5, 10, 15

(Continued)

ENG FORM 1836
NOV 01

Boring Designation CB-VK01-8

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District		SHEET 2 OF 2 SHEETS
PROJECT Virginia Key	COORDINATE SYSTEM/DATUM State Plane, FLE	HORIZONTAL NAD27	VERTICAL NGVD29
LOCATION COORDINATES X = 779,156 Y = 511,086	ELEVATION TOP OF BORING 5.5 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				53	11		SPT Sampler -11.0	5 19 41	60
			At El. -12.3 Ft., soft, trace limestone, trace aphanitie, brown	100	12		SPT Sampler -12.5	13 19 36	55
				100	13		SPT Sampler -14.0	18 39 85	124
			At El. -14.1 Ft., trace wood debris	87	14		SPT Sampler -15.5	11 38 46	84
				93	15		SPT Sampler -17.0	12 31 42	73
			At El. -17.0 Ft., trace fine to coarse-grained shell	33	16		SPT Sampler -18.5	19 27 21	48
-20.0	25.5			67	17		SPT Sampler -20.0	16 28 20	48
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System.				140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).		

DRAFT

15 20 25 30 35

Boring Designation CB-VK01-9

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION COORDINATES: X = 778,925 Y = 510,910	11. COORDINATE SYSTEM/DATUM: State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
3. DRILLING AGENCY: Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. BORING DESIGNATION: CB-VK01-9	13. TOTAL SAMPLES: DISTURBED 17; UNDISTURBED (UD) 0
5. NAME OF DRILLER: L. Wooters	14. TOTAL NUMBER CORE BOXES: 2
6. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL; BEARING	15. ELEVATION GROUND WATER: 2.0 Ft.
7. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. DATE BORING: STARTED 10-17-01; COMPLETED 10-18-01
8. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. ELEVATION TOP OF BORING: 5.5 Ft.
9. TOTAL DEPTH OF BORING: 25.5 Ft.	18. TOTAL RECOVERY FOR BORING: 71 %
	19. SIGNATURE AND TITLE OF INSPECTOR: S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
5.5	0.0		SAND, silty, mostly fine to coarse-grained shell, little quartz, little angular to subrounded fine gravel-sized gravel, little silt, strong reaction with HCl, moist, tan (SM)	93	1		5.5 SPT Sampler 4.0	3, 7, 7	14
				40	2		SPT Sampler 2.5	4, 7, 11	18
				47	3		SPT Sampler 1.0	5, 7, 10	17
			At El. 1.0 Ft., gray	27	4		SPT Sampler -0.5	3, 2, 1	3
				73	5		SPT Sampler -2.0	3, 4, 7	11
			At El. -2.5 Ft., no gravel	60	6		SPT Sampler -3.5	4, 4, 7	11
				73	7		SPT Sampler -5.0	7, 9, 30	39
				100	8		SPT Sampler -6.5	5, 4, 5	9
				93	9		SPT Sampler -8.0	4, 13, 27	40
				67	10		SPT Sampler -9.5	6, 15, 23	38

Depth scale: 0, 5, 10, 15

(Continued)

DRAFT

Boring Designation CB-VK01-9

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District		SHEET 2 OF 2 SHEETS
PROJECT Virginia Key	COORDINATE SYSTEM/DATUM State Plane, FLE	HORIZONTAL NAD27	VERTICAL NGVD29
LOCATION COORDINATES X = 778,925 Y = 510,910	ELEVATION TOP OF BORING 5.5 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
				80	11		SPT Sampler -11.0	4 9 26	35
				67	12		SPT Sampler -12.5	5 15 28	43
				73	13		SPT Sampler -14.0	5 11 24	35
				93	14		SPT Sampler -15.5	4 5 13	18
				73	15		SPT Sampler -17.0	4 11 26	37
				67	16		SPT Sampler -18.5	6 12 28	40
-20.0	25.5			73	17		SPT Sampler -20.0	4 12 27	39
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System.				140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).		

Depth scale: 15, 20, 25, 30, 35

Boring Designation CB-VK01-10

DRILLING LOG	DIVISION: South Atlantic	INSTALLATION: Jacksonville District	SHEET 1 OF 2 SHEETS

1. PROJECT: Virginia Key	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION COORDINATES: X = 777,194 Y = 509,690	11. COORDINATE SYSTEM/DATUM: State Plane, FLE; HORIZONTAL: NAD27; VERTICAL: NGVD29
3. DRILLING AGENCY: Corps Of Engineers	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. BORING DESIGNATION: CB-VK01-10	13. TOTAL SAMPLES: DISTURBED 17; UNDISTURBED (UD) 0
5. NAME OF DRILLER: L. Wooters	14. TOTAL NUMBER CORE BOXES: 1
6. DIRECTION OF BORING: ☒ VERTICAL ☐ INCLINED; DEG. FROM VERTICAL: ; BEARING:	15. ELEVATION GROUND WATER: 2.5 Ft.
7. THICKNESS OF OVERBURDEN: 0.0 Ft.	16. DATE BORING: STARTED 10-18-01; COMPLETED 10-18-01
8. DEPTH DRILLED INTO ROCK: 0.0 Ft.	17. ELEVATION TOP OF BORING: 6.0 Ft.
9. TOTAL DEPTH OF BORING: 25.5 Ft.	18. TOTAL RECOVERY FOR BORING: 66 %
	19. SIGNATURE AND TITLE OF INSPECTOR: S. Myers, Geologist

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
6.0	0.0		SAND, poorly-graded, mostly fine to medium-grained shell, some subangular to rounded fine-grained quartz, trace silt, strong reaction with HCl, dry, tan (SP)	40	1		6.0 SPT Sampler 4.5	2, 4, 5	9
				60	2		SPT Sampler 3.0	3, 4, 6	10
			At El. 3.0 Ft.	80	3 D-3		SPT Sampler 1.5	3, 6, 10	16
1.5	4.5		At El. 1.5 Ft., trace silty clay						
			SAND, silty, mostly fine to medium-grained shell, little angular to rounded fine-grained quartz, little silt, strong reaction with HCl, wet, gray (SM)	40	4		SPT Sampler 0.0	5, 5, 4	9
				53	5		SPT Sampler -1.5	5, 5, 7	12
-1.0	7.0		SAND, silty, mostly fine to coarse-grained shell, tan (SM)	73	6		SPT Sampler -3.0	4, 7, 10	17
			At El. -3.0 Ft., few silt	73	7		SPT Sampler -4.5	6, 12, 9	21
				67	8		SPT Sampler -6.0	6, 16, 28	44
				27	9		SPT Sampler -7.5	7, 15, 27	42
			At El. -7.5 Ft., little silt, gray	73	10		SPT Sampler -9.0	7, 16, 27	43

Depth scale: 0, 5, 10, 15

(Continued)

Boring Designation CB-VK01-10

DRILLING LOG (Cont. Sheet)	INSTALLATION Jacksonville District		SHEET 2 OF 2 SHEETS
PROJECT Virginia Key	COORDINATE SYSTEM/DATUM State Plane, FLE	HORIZONTAL NAD27	VERTICAL NGVD29
LOCATION COORDINATES X = 777,194 Y = 509,690	ELEVATION TOP OF BORING 6.0 Ft.		

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS	% REC.	BOX OR SAMPLE	RQD OR UD	REMARKS	BLOWS/ 0.5 FT.	N-VALUE
			At El. -9.0 Ft., some fine-grained quartz	93	11 D-11		SPT Sampler -10.5	9 24 47	71
				80	12		SPT Sampler -12.0	16 29 43	72
				67	13		SPT Sampler -13.5	16 33 61	94
				60	14 D-14		SPT Sampler -15.0	10 34 39	73
				80	15		SPT Sampler -16.5	4 14 35	49
				73	16		SPT Sampler -18.0	14 28 23	51
-19.5	25.5		At El. -17.9 Ft., soft, trace fine to coarse-grained gravel, trace limestone, trace subrounded sand, tan At El. -19.0 Ft., no gravel	80	17		SPT Sampler -19.5	6 21 22	43
			NOTES: 1. Soils are field visually classified in accordance with the Unified Soils Classification System.				140# hammer w/30 drop used with 2.0' split spoon (1-3/8 I.D. x 2" O.D.).		

15 20 25 30 35

LAWGIBB GROUP

REPORT OF LABORATORY TEST RESULTS

Virginia Key

DACW-17-01-D-0020

Delivery Order 0006

LAW Project No. 40521-1-8482-07

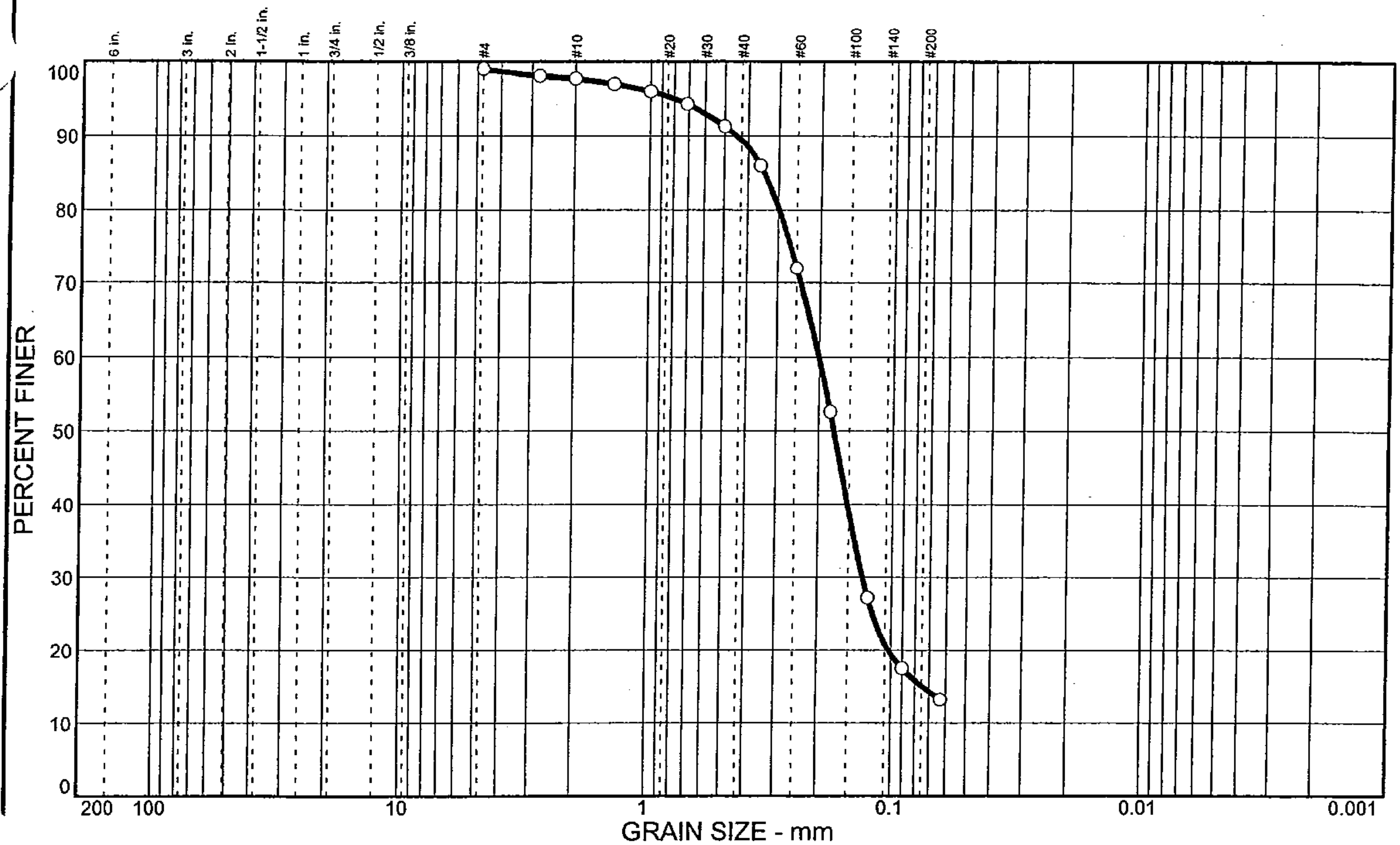
- Prepared For -

USACE

- Prepared By -

Law Engineering and Environmental Services, Inc.
3901 Carmichael Avenue
Jacksonville, Florida 32207

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			84.0	15.1		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		

	GRAIN SIZE		
D_{60}	0.201		
D_{30}	0.131		
D_{10}			

	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	99.0		
#7	98.1		
#10	97.7		
#14	97.0		
#18	96.0		
#25	94.3		
#35	91.3		
#45	86.0		
#60	72.1		
#80	52.6		
#120	27.2		
#170	17.5		
#230	13.2		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some shell, little silt, light brown

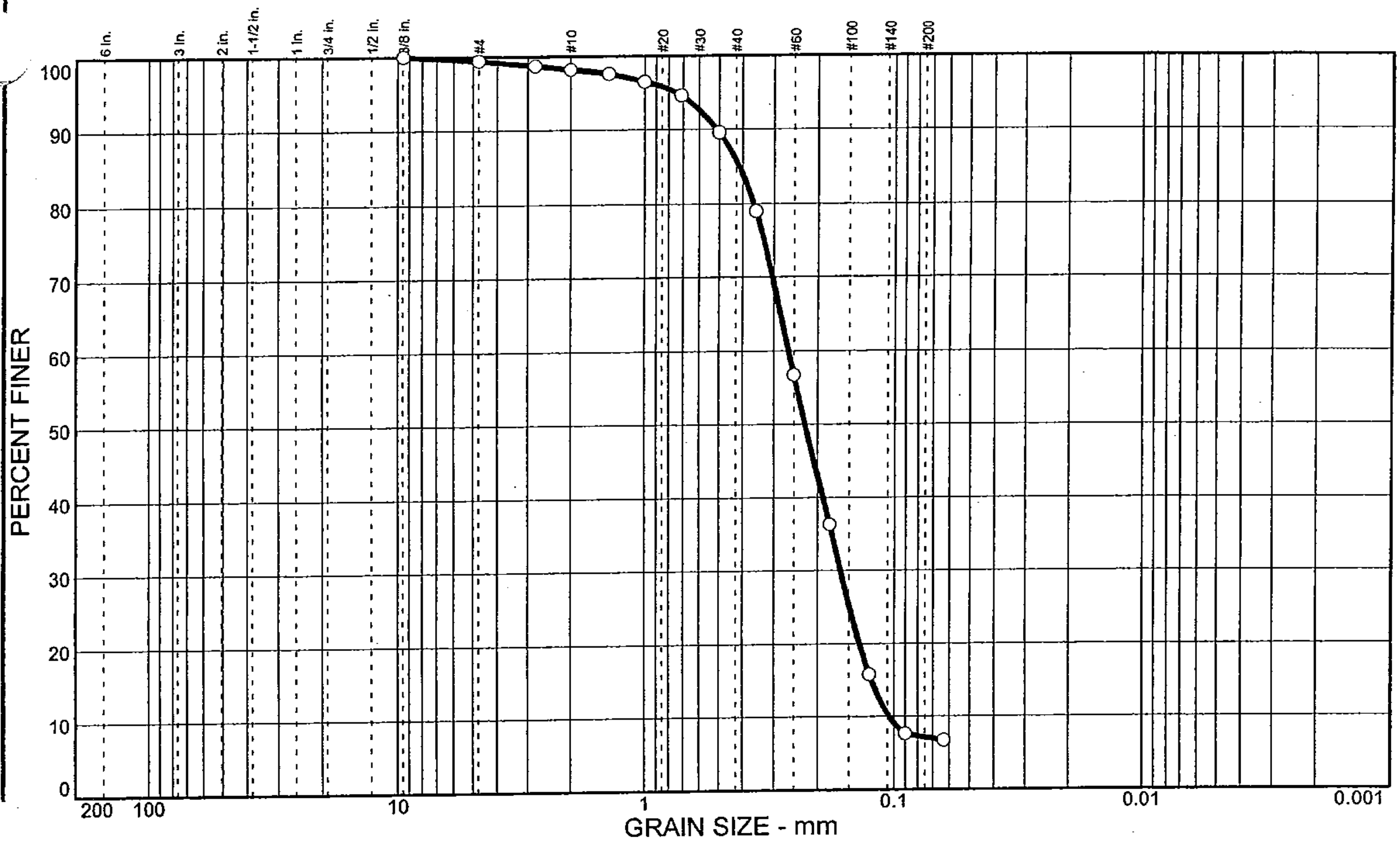
REMARKS:

○ Fresh Water Pond-Area 4
Visual Percent Shell: 67%

○ Source: CB-VK01-4 Sample No.: D-4 Elev./Depth: 4.5'-5.0'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.6	92.3	7.1		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.263		
D_{30}	0.163		
D_{10}	0.104		
	COEFFICIENTS		
C_c	0.97		
C_u	2.52		

SIEVE number size	PERCENT FINER ○		
#4	99.4		
#7	98.7		
#10	98.2		
#14	97.6		
#18	96.5		
#25	94.6		
#35	89.6		
#45	79.0		
#60	56.7		
#80	36.3		
#120	15.8		
#170	7.6		
#230	6.7		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some course to fine sand sized shell fragments, trace sandstone, trace silt, gray and light brown

REMARKS:

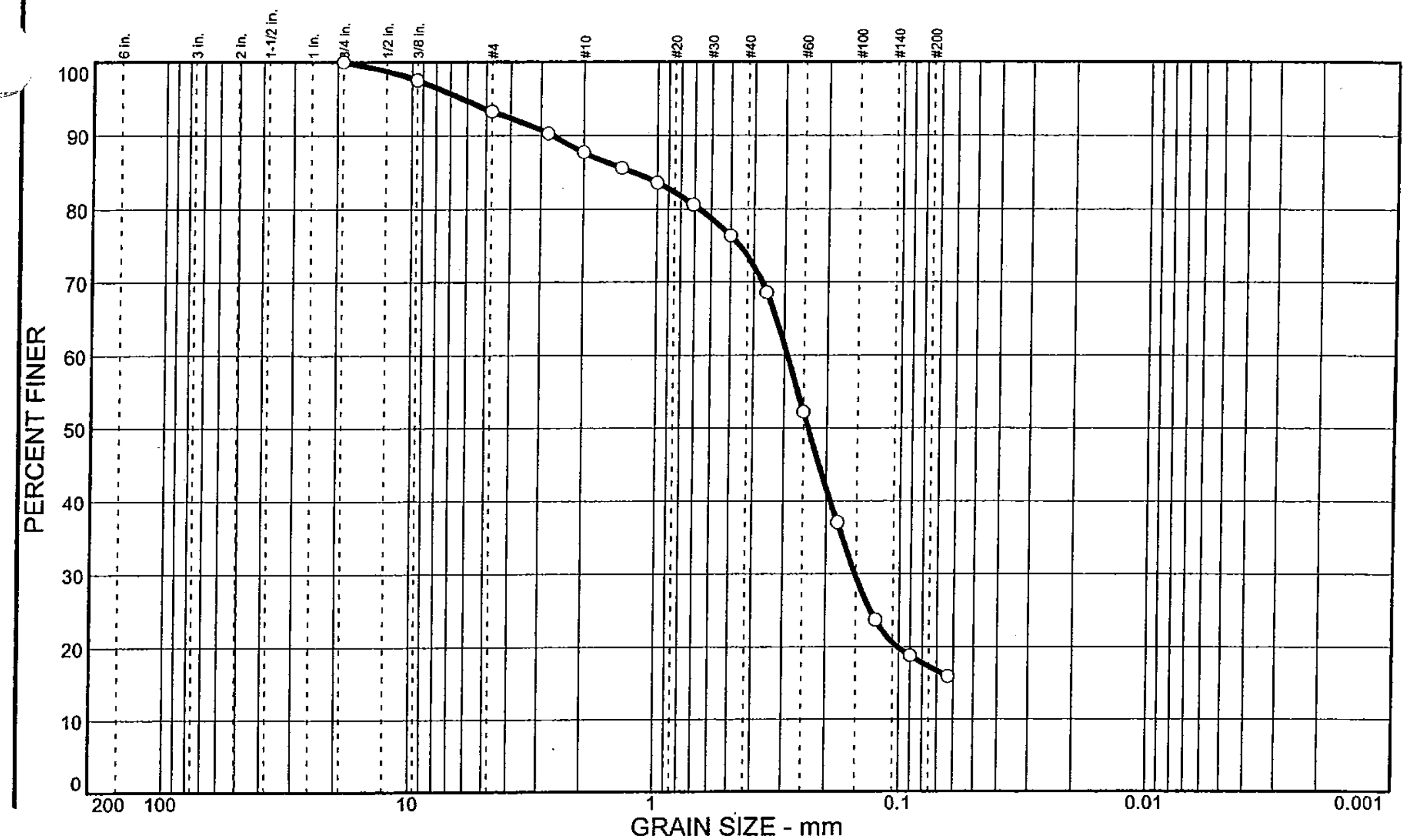
○ Fresh Water Pond-Area 4
Visual Percent Shell: 69%

○ Source: CB-VK01-4 Sample No.: D-6 Elev./Depth: 7.5'-9.0'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		6.7	76.1	17.2		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/4	100.0		
3/8	97.5		
	GRAIN SIZE		
D_{60}	0.292		
D_{30}	0.152		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER O		
#4	93.3		
#7	90.3		
#10	87.7		
#14	85.6		
#18	83.6		
#25	80.6		
#35	76.4		
#45	68.6		
#60	52.2		
#80	37.0		
#120	23.7		
#170	18.8		
#230	15.9		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some medium to fine sand sized shell fragments, little silt, trace coarse limestone, light brown-tan

REMARKS:

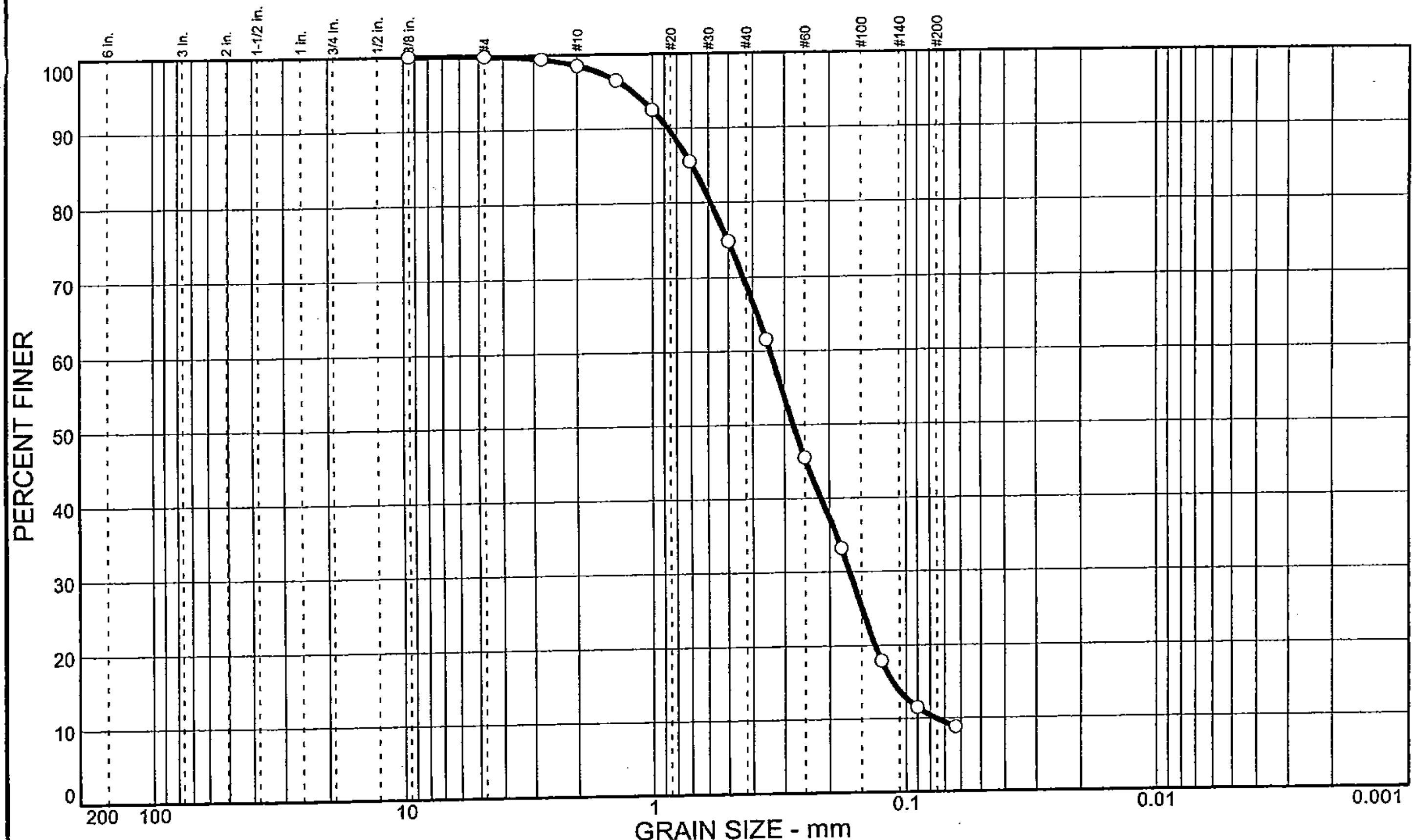
O Fresh Water Pond-Area 4
Visual Percent Shell: 39%

O Source: CB-VK01-5 Sample No.: 2 Elev./Depth: 1.5'-3.0'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		0.1	90.0	9.9		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.343		
D_{30}	0.167		
D_{10}	0.0759		
	COEFFICIENTS		
C_c	1.07		
C_u	4.52		

SIEVE number size	PERCENT FINER O		
#4	99.9		
#7	99.4		
#10	98.5		
#14	96.5		
#18	92.5		
#25	85.5		
#35	74.8		
#45	61.5		
#60	45.5		
#80	33.2		
#120	17.9		
#170	11.5		
#230	8.8		

SOIL DESCRIPTION

O SAND, medium to fine quartz, trace organic, trace silt, some sand sized shell fragments, gray and dark brown

REMARKS:

O Fresh Water Pond-Area 4
Visual Percent Shell: 60%

O Source: CB-VK01-5

Sample No.: 5

Elev./Depth: 6.0'-7.5'

Law Engineering and Environmental Services, Inc.

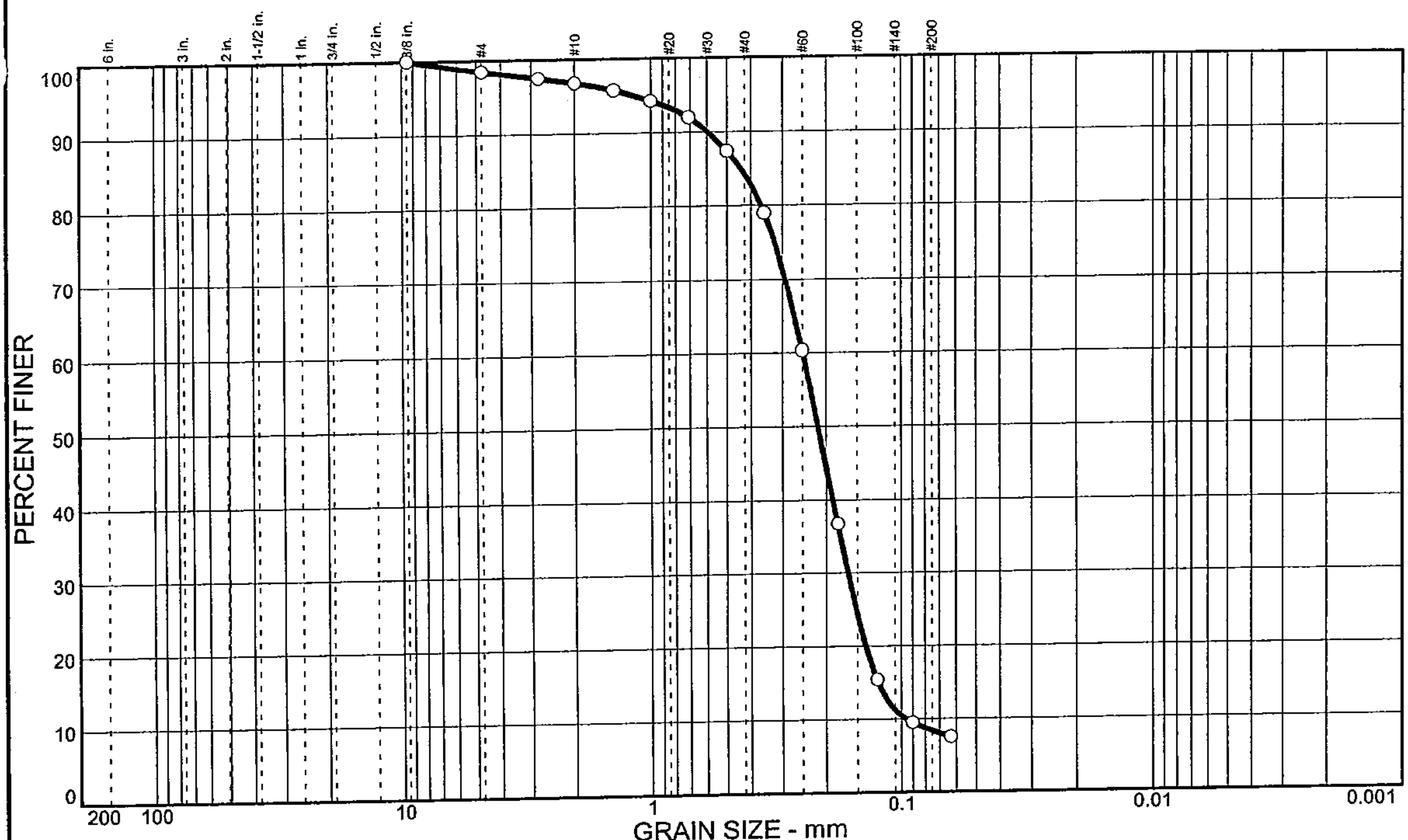
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		1.5	90.1	8.4		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.249		
D_{30}	0.164		
D_{10}	0.0957		
	COEFFICIENTS		
C_c	1.12		
C_u	2.60		

SIEVE number size	PERCENT FINER O		
#4	98.5		
#7	97.5		
#10	96.8		
#14	95.8		
#18	94.3		
#25	92.0		
#35	87.4		
#45	79.0		
#60	60.3		
#80	36.7		
#120	15.4		
#170	9.5		
#230	7.5		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some course to fine sand sized shell fragments, trace silt, light brown-tan

REMARKS:

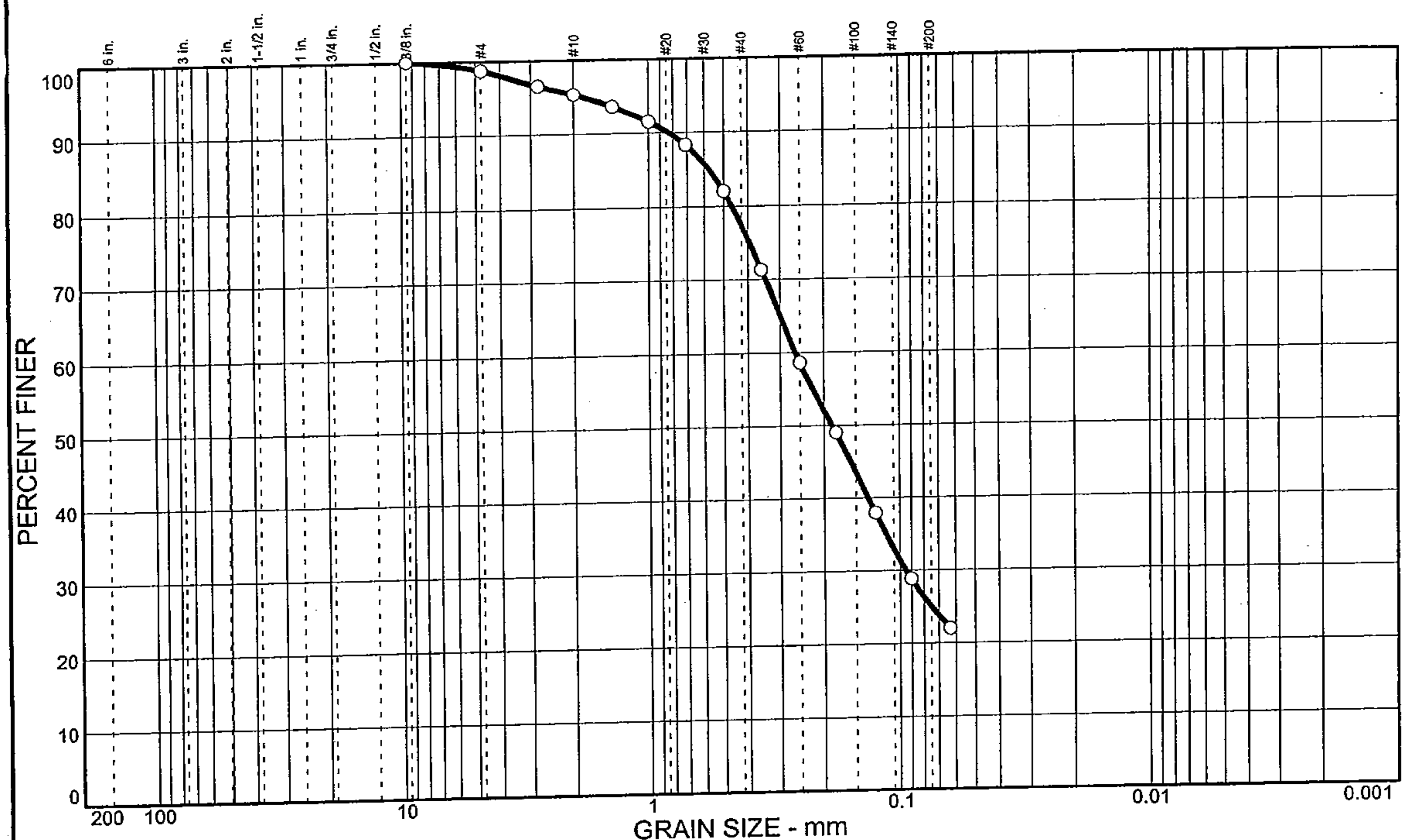
O Fresh Water Pond-Area 4
Visual Percent Shell: 60%

O Source: CB-VK01-6 Sample No.: 2 Elev./Depth: 1.5'-3.0'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		1.3	73.7	25.0		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.261		
D_{30}	0.0946		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	98.7		
#7	96.5		
#10	95.3		
#14	93.6		
#18	91.5		
#25	88.3		
#35	82.0		
#45	71.4		
#60	58.6		
#80	49.0		
#120	37.9		
#170	28.8		
#230	22.0		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, some silt, trace organic, gray and dark brown

REMARKS:

○ Fresh Water Pond-Area 4
Visual Percent Shell: 48%

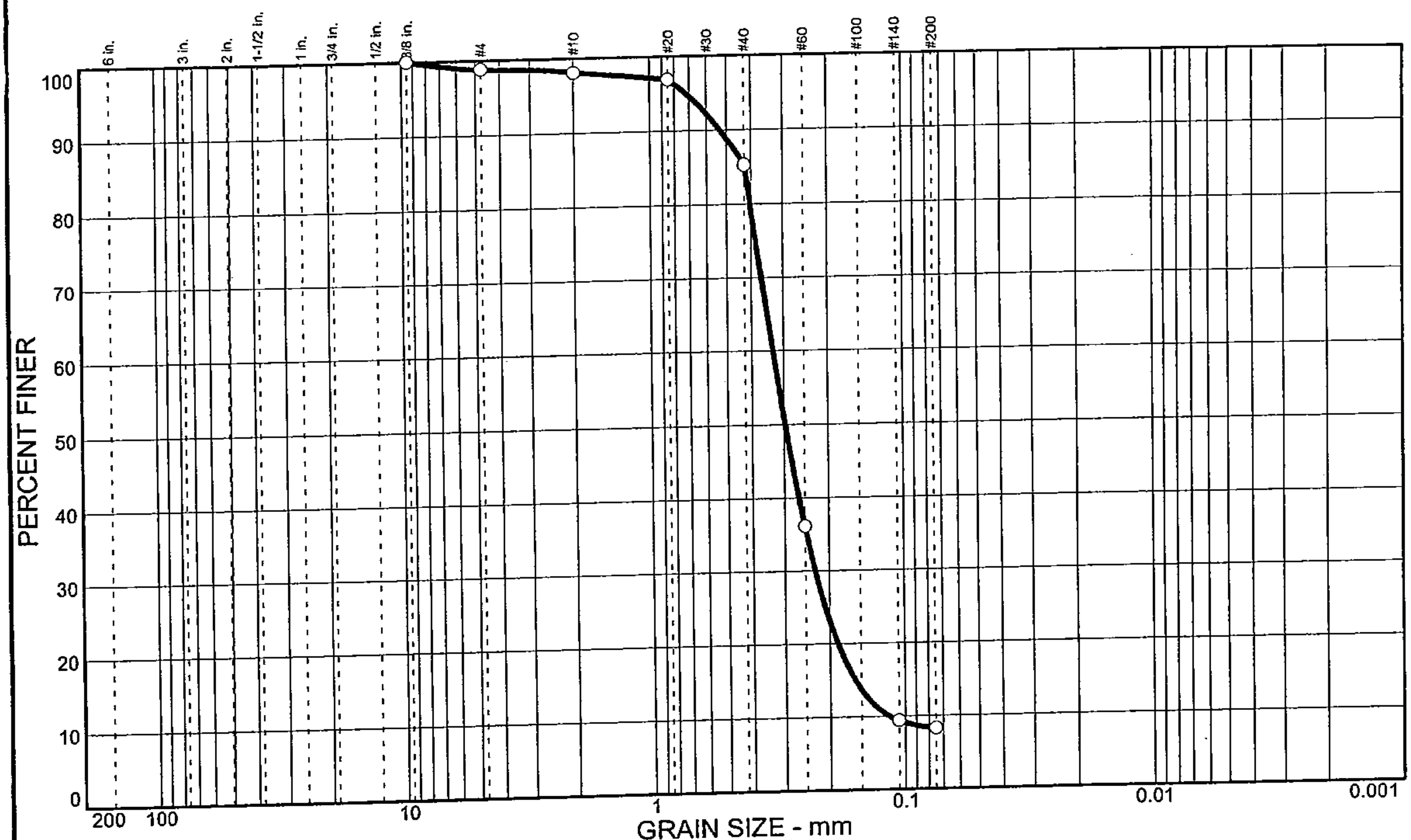
○ Source: CB-VK01-6

Sample No.: 5

Elev./Depth: 6.0'-7.5'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		1.2	90.5	8.3		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
.375	100.0		

	GRAIN SIZE		
D_{60}	0.330		
D_{30}	0.228		
D_{10}	0.115		

	COEFFICIENTS		
C_c	1.36		
C_u	2.86		

SIEVE number size	PERCENT FINER ○		
#4	98.8		
#10	98.1		
#20	96.9		
#40	85.3		
#60	36.1		
#140	9.4		
#200	8.3		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, trace silt, trace sand sized shell fragments, dark brown and gray

REMARKS:

○ Groin Foundation-Area 5

○ Source: CB-VK01-7 Sample No.: 3 Elev./Depth: 3.0'-4.5'

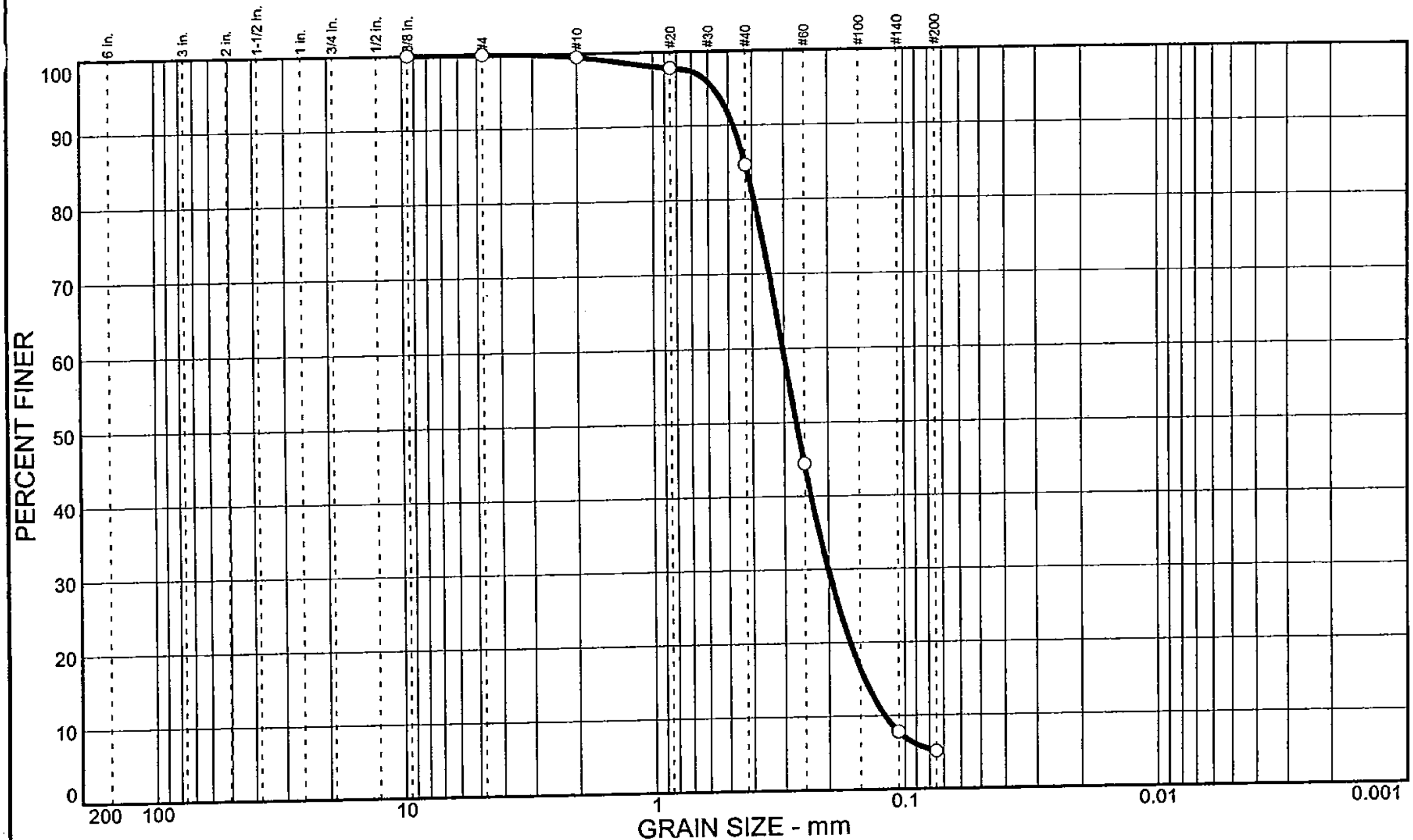
Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			94.9	5.1		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
.375	100.0		
	GRAIN SIZE		
D_{60}	0.304		
D_{30}	0.201		
D_{10}	0.120		
	COEFFICIENTS		
C_c	1.11		
C_u	2.53		

O Source: CB-VK01-7

SIEVE number size	PERCENT FINER O		
#4	100.0		
#10	99.5		
#20	97.8		
#40	84.7		
#60	44.4		
#140	7.8		
#200	5.1		

Sample No.: 7

SOIL DESCRIPTION

O SAND, fine quartz, trace sand sized shell fragments, trace silt, gray

REMARKS:

O Groin Foundation-Area 5

Elev./Depth: 9.0'-10.5'

Law Engineering and Environmental Services, Inc.

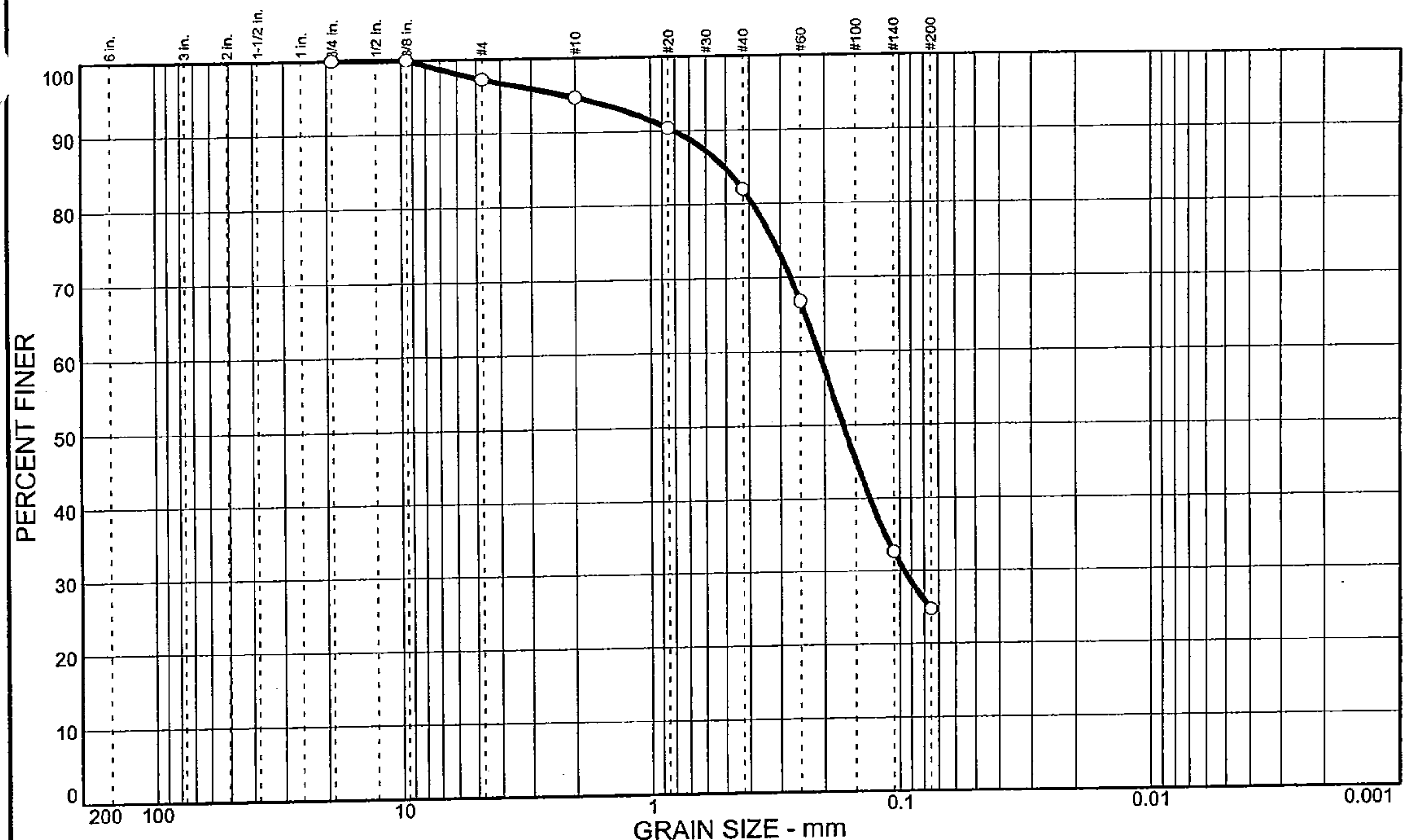
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.7	72.6	24.7		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
.75	100.0		
.375	100.0		
	GRAIN SIZE		
D_{60}	0.212		
D_{30}	0.0962		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER O		
#4	97.3		
#10	94.7		
#20	90.4		
#40	82.0		
#60	66.7		
#140	32.6		
#200	24.7		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some silt, trace organics, brown

REMARKS:

O Groin Foundation-Area 5

O Source: CB-VK01-8

Sample No.: 1

Elev./Depth: 0.0'-1.5'

Law Engineering and Environmental Services, Inc.

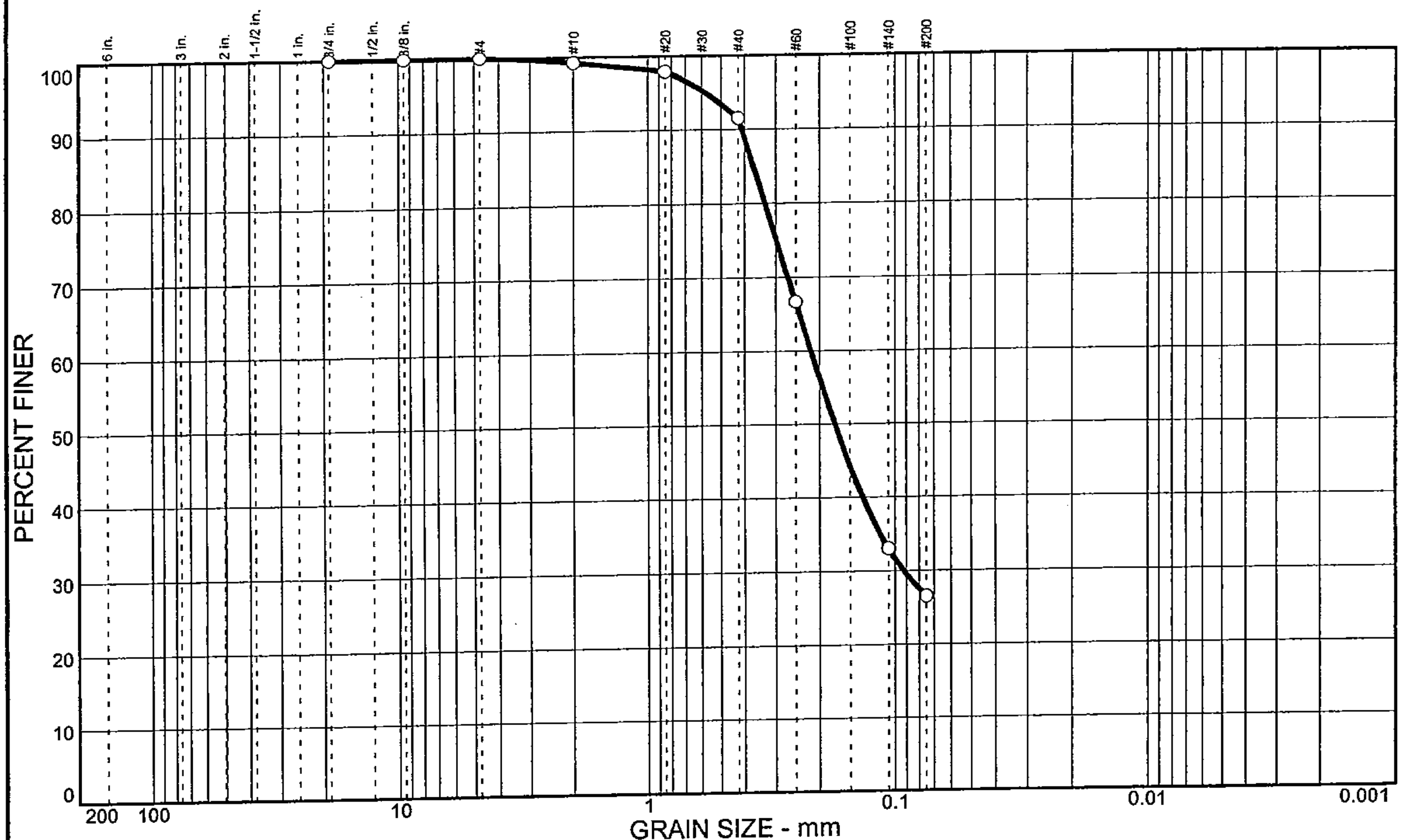
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			73.5	26.5		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
.75	100.0		
.375	100.0		
	GRAIN SIZE		
D_{60}	0.217		
D_{30}	0.0922		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.2		
#20	97.9		
#40	91.5		
#60	66.7		
#140	33.0		
#200	26.5		

SOIL DESCRIPTION

○ SAND, fine quartz, some silt, gray and brown

REMARKS:

○ Groin Foundation-Area 5

○ Source: CB-VK01-8

Sample No.: 4

Elev./Depth: 4.5'-6.0'

Law Engineering and Environmental Services, Inc.

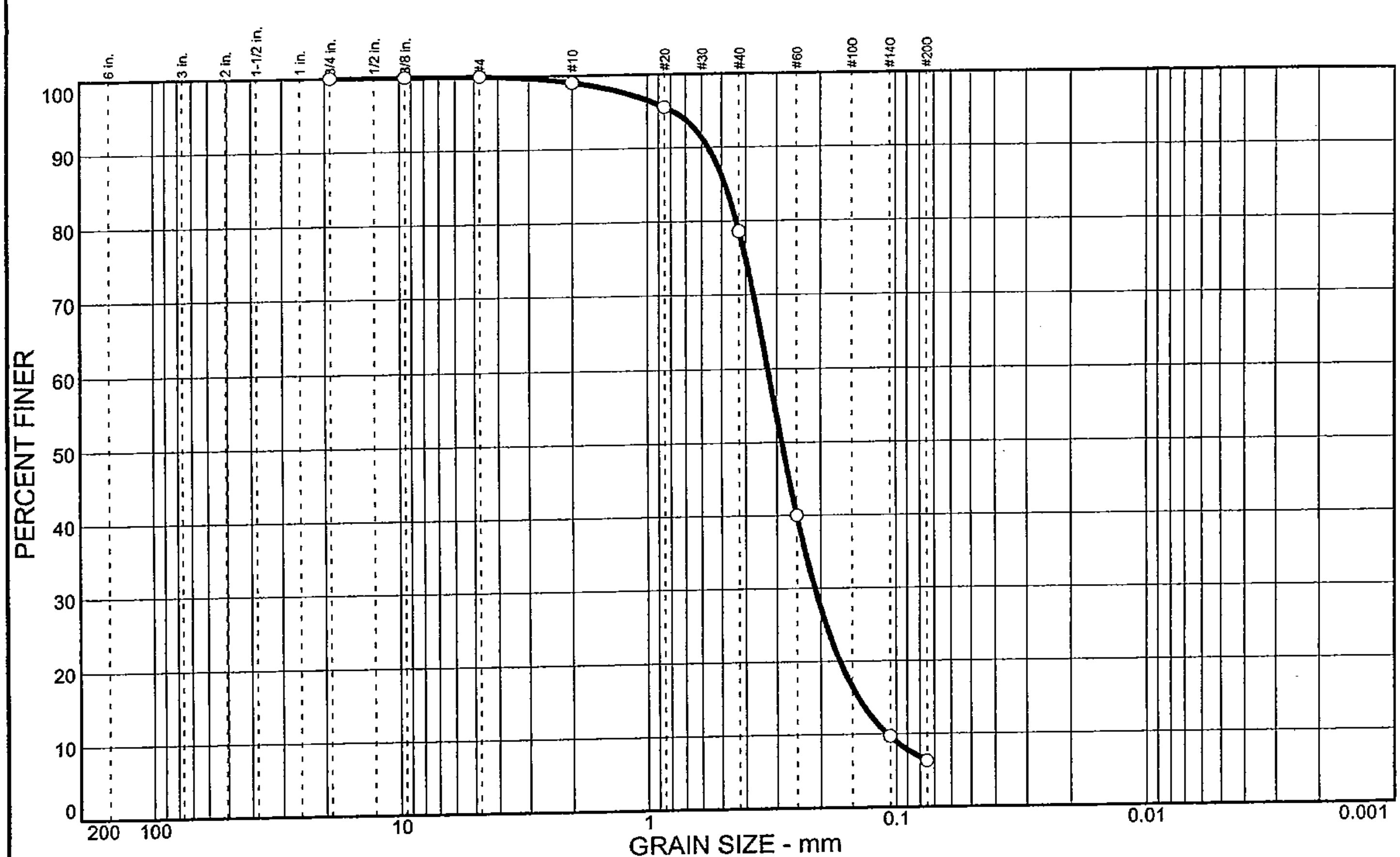
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			93.7	6.3		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
.75	100.0		
.375	100.0		

	GRAIN SIZE		
D_{60}	0.326		
D_{30}	0.211		
D_{10}	0.108		

	COEFFICIENTS		
C_c	1.26		
C_u	3.01		

○ Source: CB-VK01-9

SIEVE number size	PERCENT FINER ○		
#4	100.0		
#10	99.0		
#20	95.5		
#40	78.6		
#60	40.0		
#140	9.7		
#200	6.3		

Sample No.: 5

SOIL DESCRIPTION

○ SAND, medium to fine quartz, trace silt, gray

REMARKS:

○

Elev./Depth: 6.0'-7.5'

Law Engineering and Environmental Services, Inc.

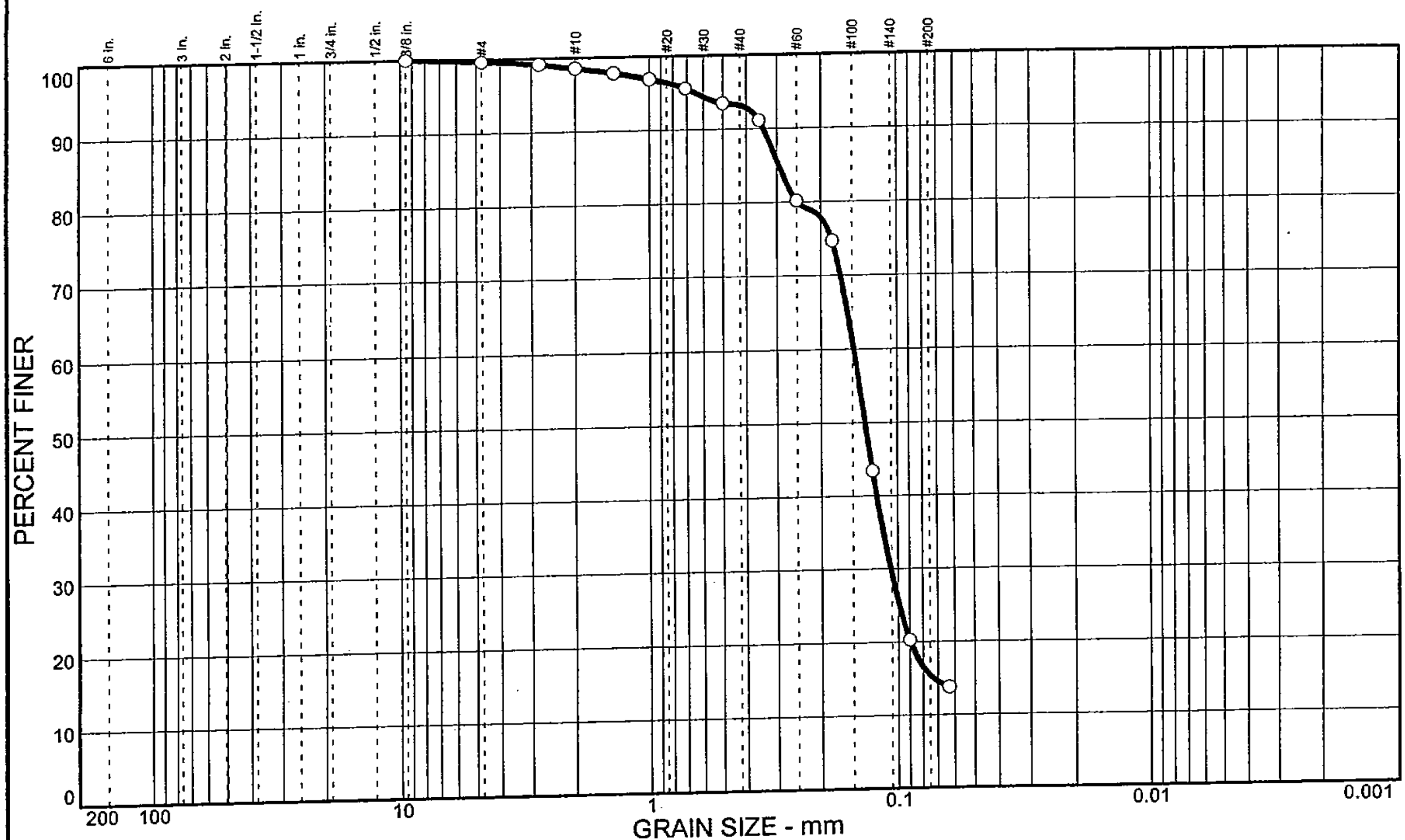
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.4	84.2	15.4		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.148		
D_{30}	0.107		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	99.6		
#7	99.1		
#10	98.5		
#14	97.8		
#18	96.9		
#25	95.6		
#35	93.5		
#45	91.1		
#60	80.2		
#80	74.7		
#120	43.4		
#170	20.3		
#230	13.8		

SOIL DESCRIPTION

○ SAND, fine quartz, some sand sized shell fragments, little silt, light brown-tan

REMARKS:

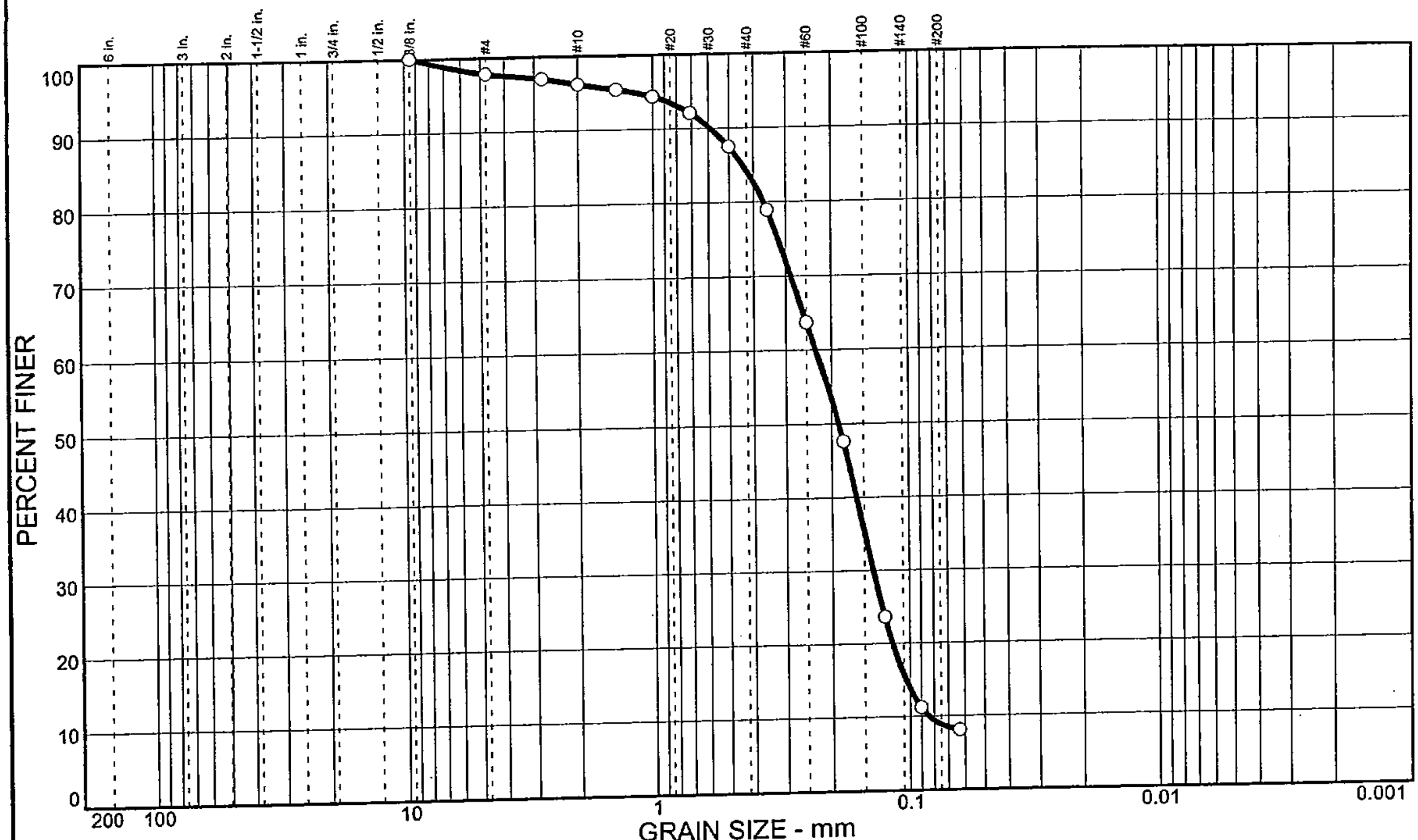
○ South Sand Mound Test Pit
Visual Percent Shell: 86%

○ Source: TP-VKSM101-1 Sample No.: 1' Elev./Depth: +5.4'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.2	89.0	8.8		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.230		
D_{30}	0.138		
D_{10}	0.0839		
	COEFFICIENTS		
C_c	0.99		
C_u	2.75		

SIEVE number size	PERCENT FINER O		
#4	97.8		
#7	97.0		
#10	96.2		
#14	95.4		
#18	94.4		
#25	92.1		
#35	87.5		
#45	78.9		
#60	63.7		
#80	47.6		
#120	23.6		
#170	11.2		
#230	8.1		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some course to fine sand sized shell fragments, trace silt, brown

REMARKS:

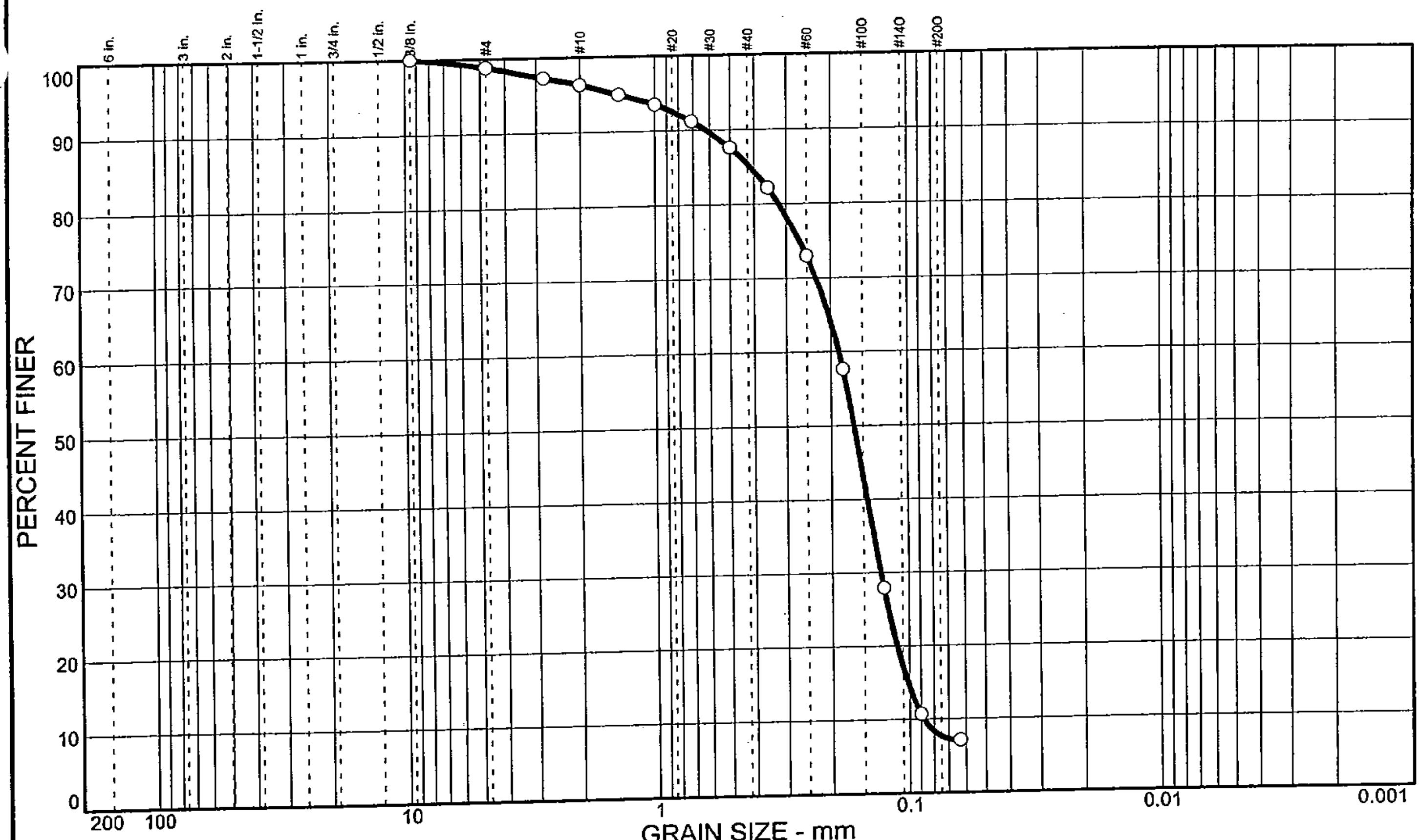
O South Sand Mound Test Pits
Visual Percent Shell: 52%

O Source: TP-VKSM101-1 Sample No.: 5' Elev./Depth: +9.4'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		1.2	91.1	7.7		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.187		
D_{30}	0.128		
D_{10}	0.0876		
	COEFFICIENTS		
C_c	1.01		
C_u	2.13		

SIEVE number size	PERCENT FINER ○		
#4	98.8		
#7	97.3		
#10	96.3		
#14	94.9		
#18	93.5		
#25	91.2		
#35	87.6		
#45	82.2		
#60	73.0		
#80	57.6		
#120	27.9		
#170	10.7		
#230	7.1		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, trace silt, brown

REMARKS:

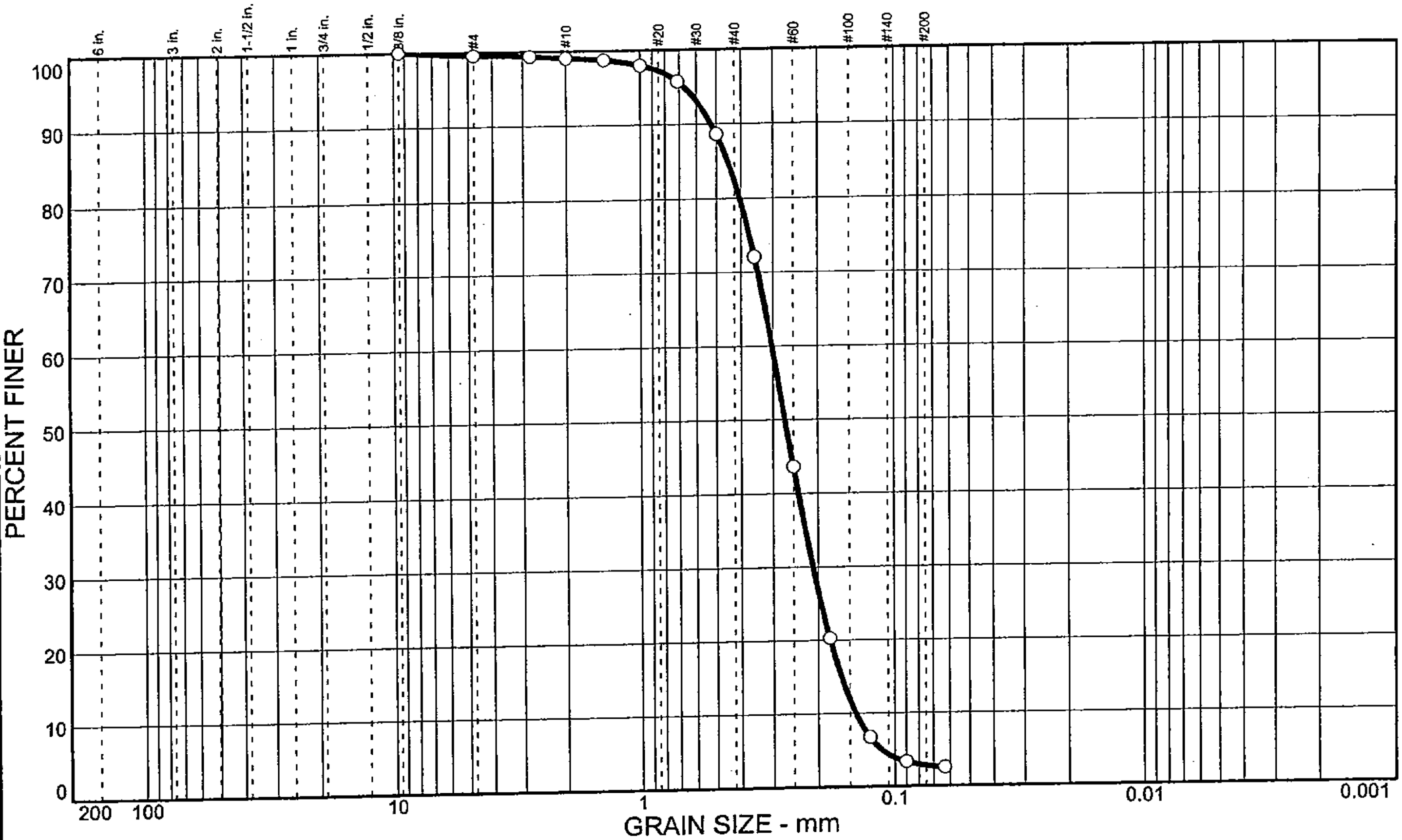
○ South Sand Mound Test Pits
Visual Percent Shell: 59%

○ Source: TP-VKSM101-1 Sample No.: 7' Elev./Depth: +11.4'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		0.5	96.7	2.8		SP	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.303		
D_{30}	0.210		
D_{10}	0.142		
	COEFFICIENTS		
C_c	1.02		
C_u	2.14		

O Source: TP-VKSM101-2

SIEVE number size	PERCENT FINER O		
#4	99.5		
#7	99.3		
#10	99.0		
#14	98.7		
#18	97.9		
#25	95.7		
#35	88.6		
#45	72.2		
#60	43.6		
#80	20.3		
#120	6.7		
#170	3.3		
#230	2.5		

Sample No.: 1'

SOIL DESCRIPTION

O SAND, medium to fine quartz, some sand sized shell fragments, brown

REMARKS:

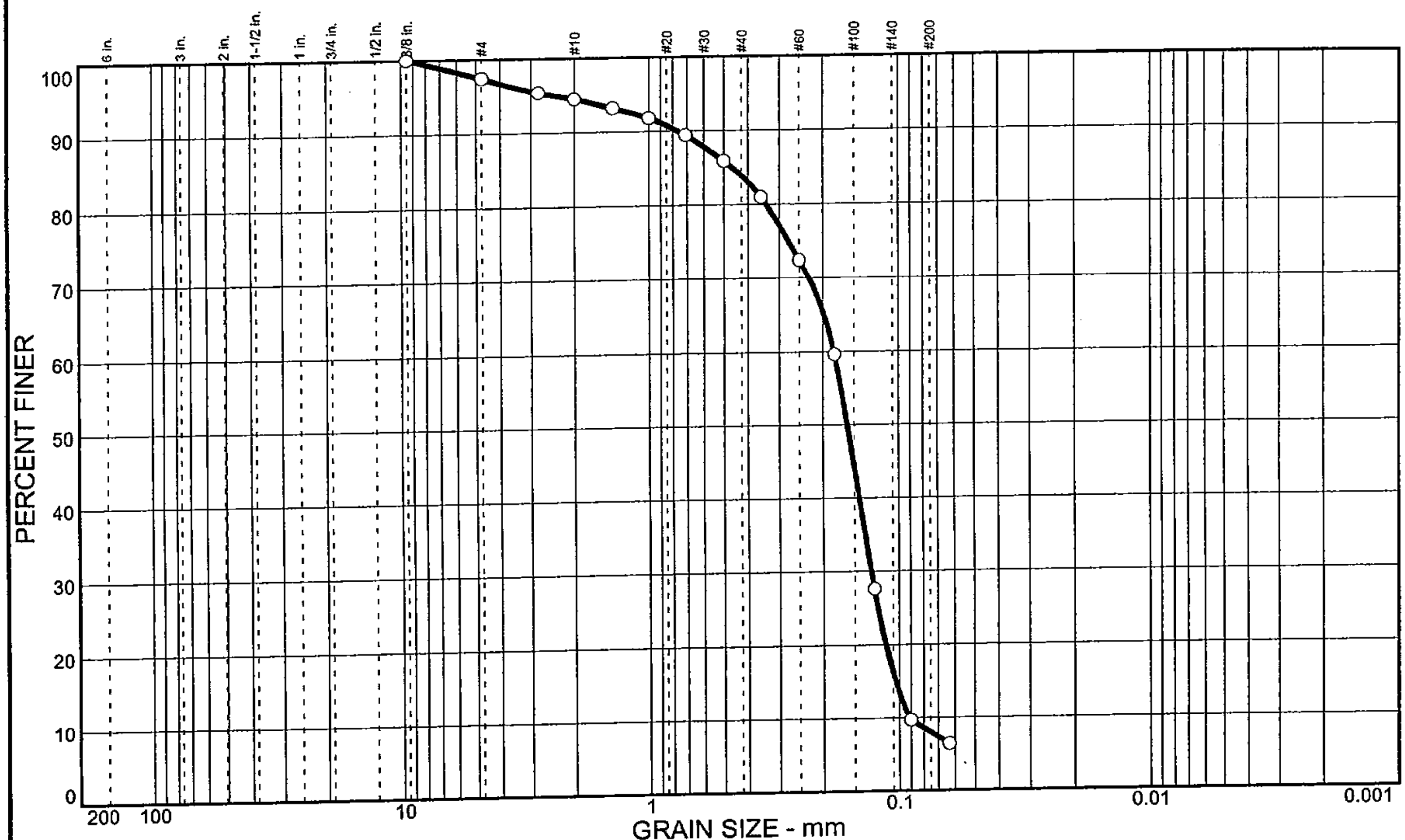
O South Sand Mound Test Pits
Visual Percent Shell: 81%

Elev./Depth: +7.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.6	89.4	8.0		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.181		
D_{30}	0.129		
D_{10}	0.0909		
	COEFFICIENTS		
C_c	1.00		
C_u	1.99		

SIEVE number size	PERCENT FINER O		
#4	97.4		
#7	95.4		
#10	94.5		
#14	93.2		
#18	91.8		
#25	89.4		
#35	85.9		
#45	81.0		
#60	72.5		
#80	59.6		
#120	27.6		
#170	9.7		
#230	6.4		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some sand sized shell fragments, trace silt, brown

REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 71%

o Source: TP-VKSM101-2

Sample No.: 3'

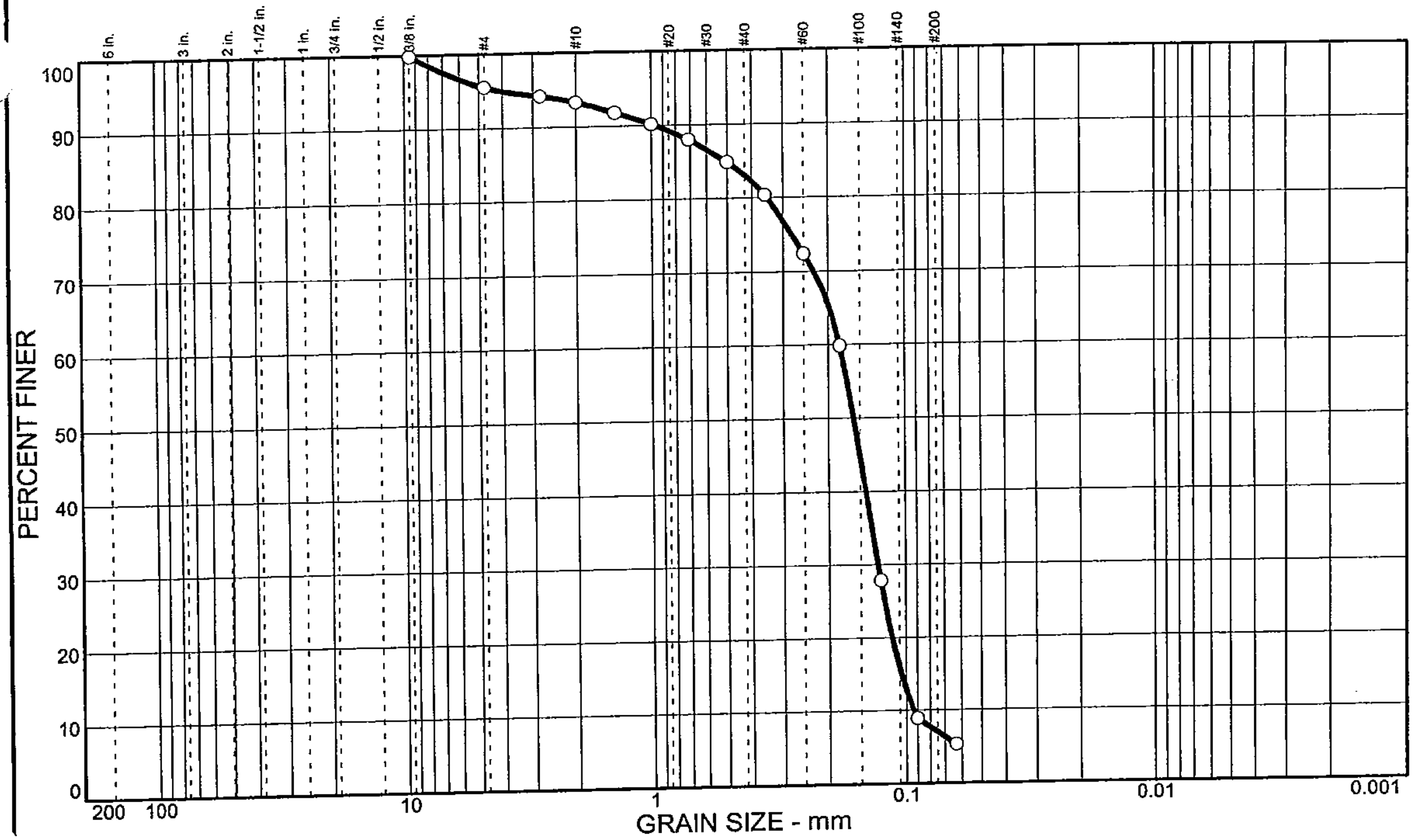
Elev./Depth: +9.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			88.4	7.1		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	99.8		

	GRAIN SIZE		
D_{60}	0.181		
D_{30}	0.128		
D_{10}	0.0930		

	COEFFICIENTS		
C_c	0.98		
C_u	1.94		

SIEVE number size	PERCENT FINER O		
#4	95.5		
#7	94.2		
#10	93.3		
#14	91.8		
#18	90.2		
#25	88.0		
#35	84.9		
#45	80.4		
#60	72.4		
#80	59.8		
#120	27.8		
#170	8.9		
#230	5.3		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some course to fine shell fragments, trace silt, brown

REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 69%

O Source: TP-VKSM101-2

Sample No.: 5'

Elev./Depth: +11.8'

Law Engineering and Environmental Services, Inc.

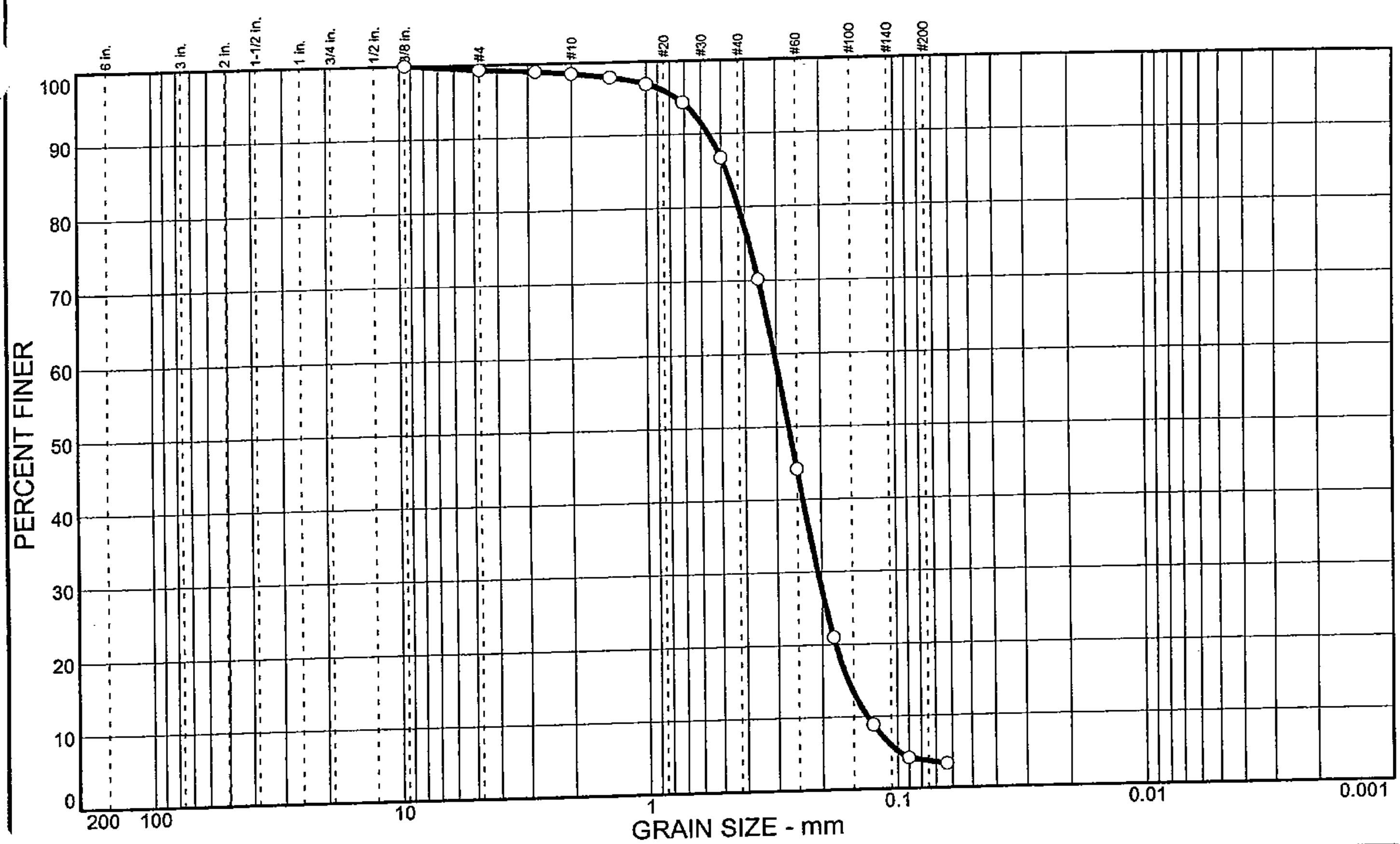
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		0.7	95.6	3.7		SP	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.306		
D_{30}	0.208		
D_{10}	0.132		
	COEFFICIENTS		
C_c	1.07		
C_u	2.33		

SIEVE number size	PERCENT FINER O		
#4	99.3		
#7	98.9		
#10	98.5		
#14	97.9		
#18	96.9		
#25	94.3		
#35	86.7		
#45	70.2		
#60	44.2		
#80	21.0		
#120	8.9		
#170	4.2		
#230	3.3		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some sand sized shell fragments, brown

REMARKS:

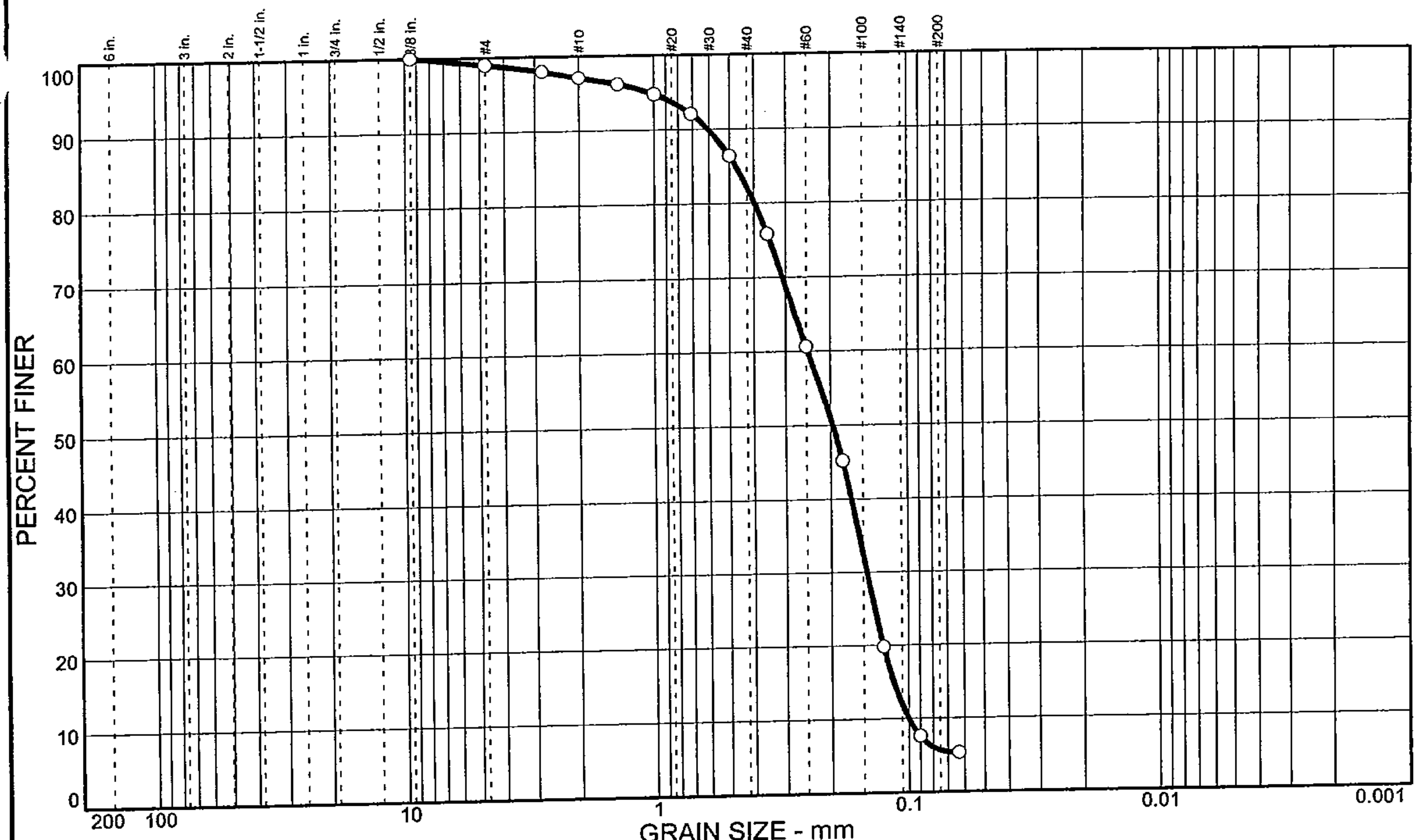
O South Sand Mound Test Pits
Visual Percent Shell: 54%

O Source: TP-VKSM101-3 | Sample No.: 2' | Elev./Depth: +9.9'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		1.0	93.3	5.7		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.246		
D_{30}	0.145		
D_{10}	0.0998		
	COEFFICIENTS		
C_c	0.86		
C_u	2.47		

SIEVE number size	PERCENT FINER O		
#4	99.0		
#7	98.0		
#10	97.1		
#14	96.2		
#18	94.8		
#25	92.1		
#35	86.4		
#45	75.9		
#60	60.6		
#80	45.2		
#120	19.8		
#170	7.6		
#230	5.3		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some course to fine sand sized shell fragments, trace silt, brown

REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 51%

O Source: TP-VKSM101-3

Sample No.: 5'

Elev./Depth: +12.9'

Law Engineering and Environmental Services, Inc.

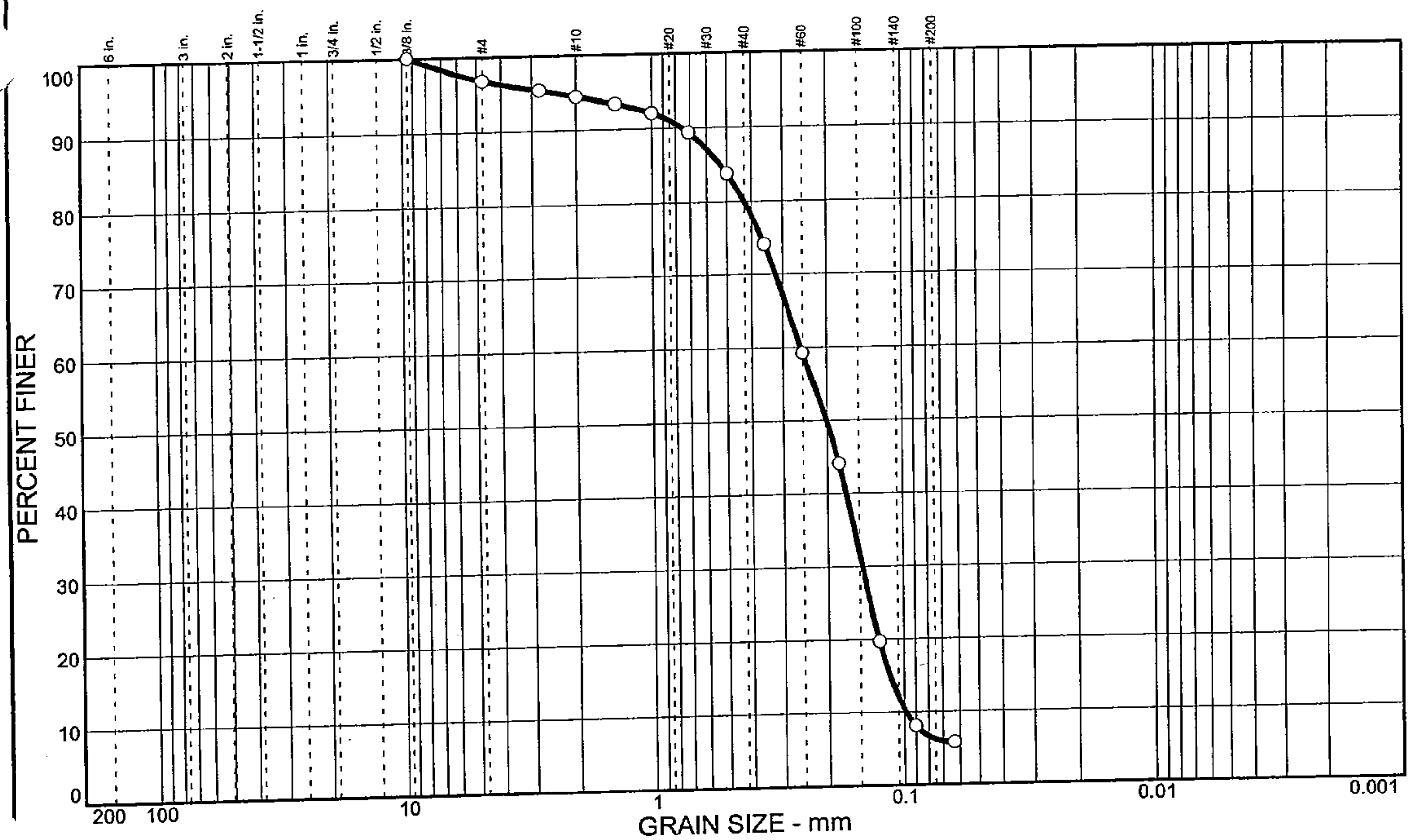
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		3.2	90.6	6.2		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.255		
D_{30}	0.146		
D_{10}	0.0984		
	COEFFICIENTS		
C_c	0.85		
C_u	2.59		

O Source: TP-VKSM101-3

SIEVE number size	PERCENT FINER O		
#4	96.8		
#7	95.4		
#10	94.5		
#14	93.4		
#18	92.1		
#25	89.4		
#35	83.8		
#45	74.2		
#60	59.2		
#80	44.1		
#120	19.7		
#170	8.1		
#230	5.8		

Sample No.: 8'

SOIL DESCRIPTION

O SAND, medium to fine quartz, some medium to fine sand sized shell fragments, trace sand sized limestone fragments, trace silt, brown

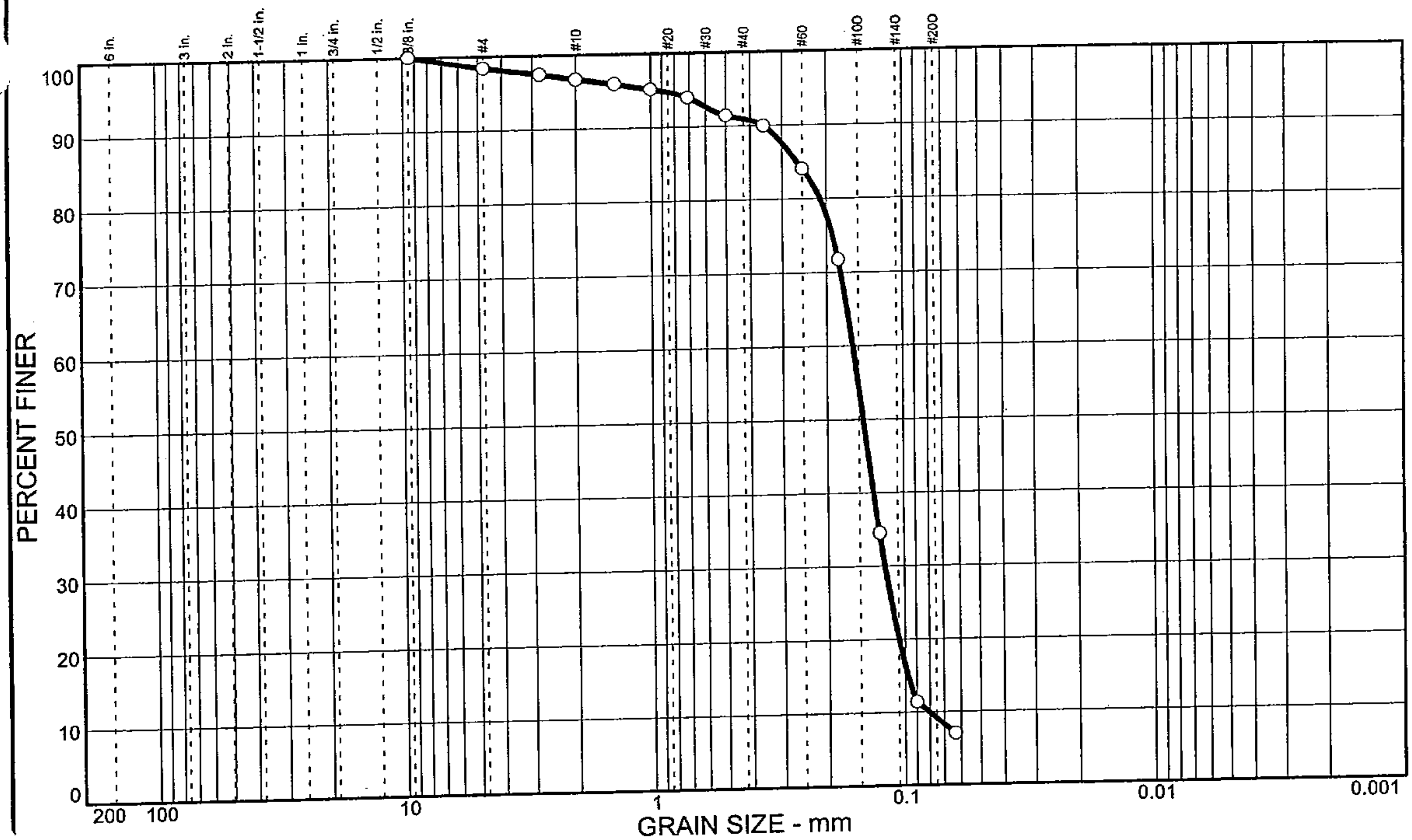
REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 38%

Elev./Depth: +15.9'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		1.6	89.3	9.1		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.158		
D_{30}	0.119		
D_{10}	0.0803		
	COEFFICIENTS		
C_c	1.12		
C_u	1.97		

SIEVE number size	PERCENT FINER O		
#4	98.4		
#7	97.4		
#10	96.7		
#14	96.0		
#18	95.2		
#25	94.0		
#35	91.5		
#45	90.0		
#60	84.1		
#80	71.8		
#120	34.5		
#170	11.4		
#230	7.0		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some fine sand sized shell fragments, trace limestone fragments, trace silt, light brown

REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 50%

O Source: TP-VKSM101-4

Sample No.: 2'

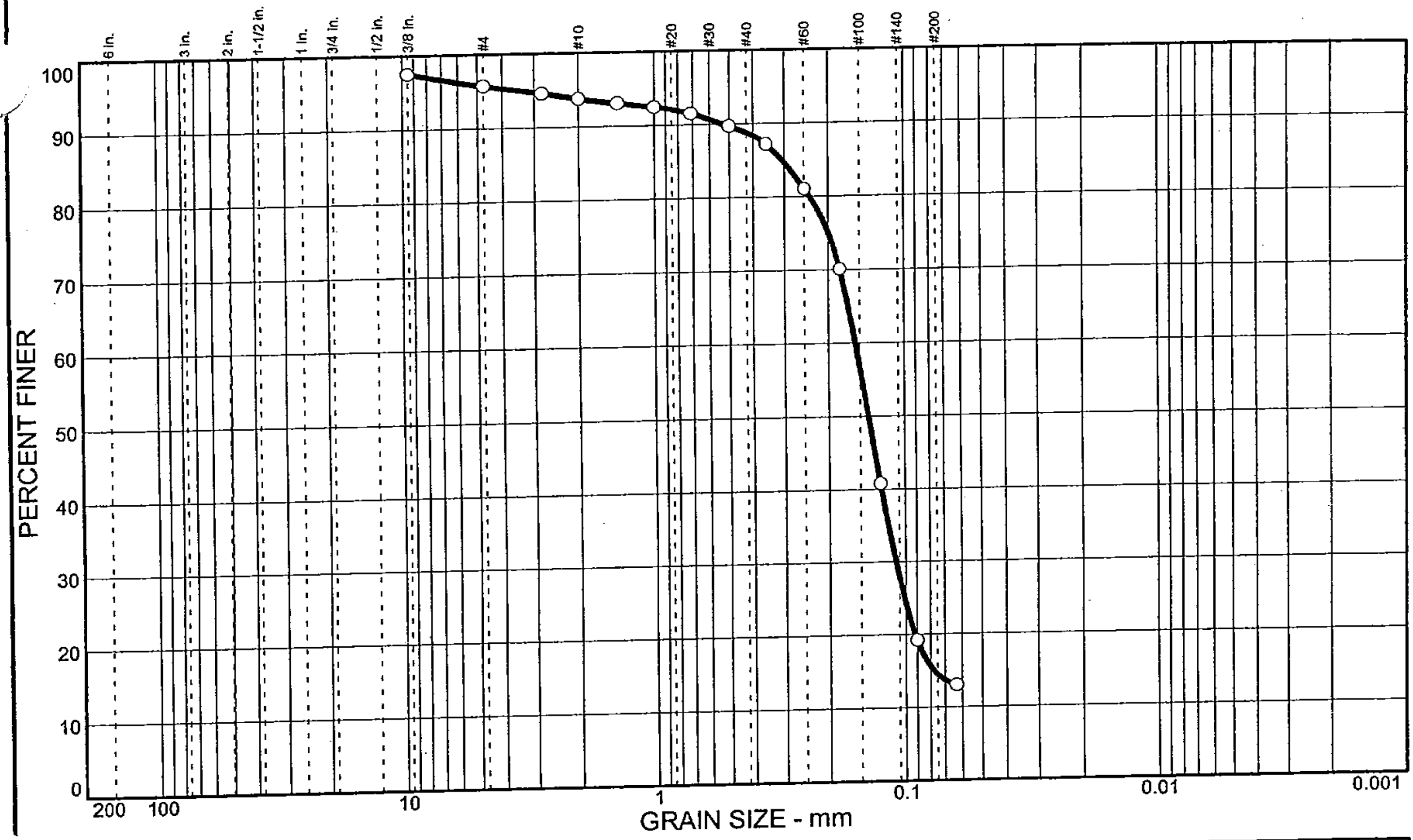
Elev./Depth: +6.9'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			81.2	14.5		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/8	97.5		
	GRAIN SIZE		
D_{60}	0.156		
D_{30}	0.109		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER O		
#4	95.7		
#7	94.6		
#10	93.8		
#14	93.1		
#18	92.5		
#25	91.5		
#35	89.7		
#45	87.2		
#60	81.1		
#80	70.1		
#120	40.8		
#170	19.2		
#230	13.0		

SOIL DESCRIPTION

O SAND, fine quartz, some medium to fine sand sized shell fragments, little silt, trace limestone fragments, brown

REMARKS:

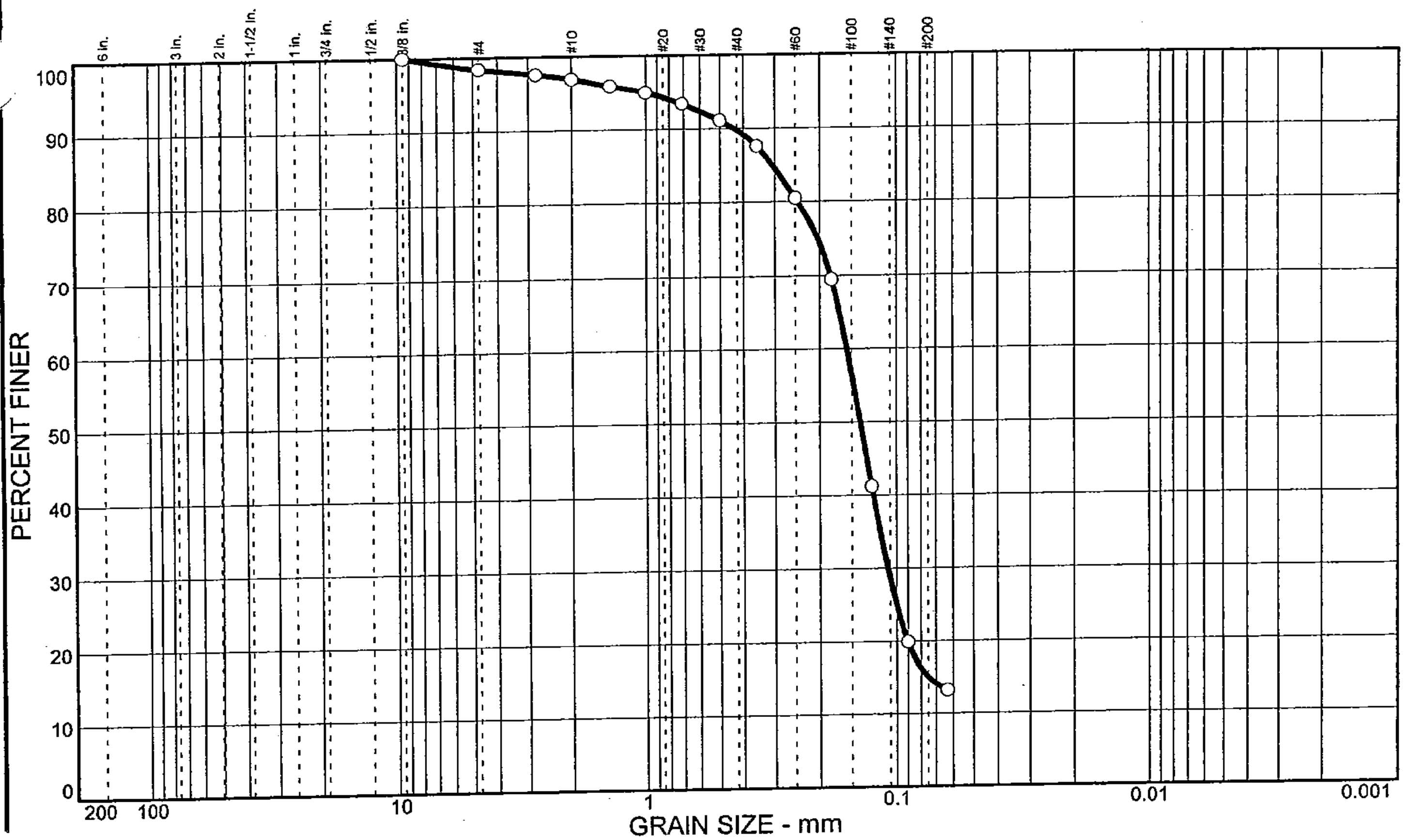
O South Sand Mound Test Pits
Visual Percent Shell: 40%

O Source: TP-VKSM101-4   Sample No.: 3.5'   Elev./Depth: +8.4'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07   Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		1.6	83.4	15.0		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.157		
D_{30}	0.108		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER O		
#4	98.4		
#7	97.6		
#10	96.9		
#14	95.9		
#18	95.0		
#25	93.4		
#35	91.1		
#45	87.6		
#60	80.5		
#80	69.5		
#120	41.2		
#170	19.9		
#230	13.2		

SOIL DESCRIPTION

O SAND, medium to fine quartz, little sand sized shell fragments, little silt, brown-light brown

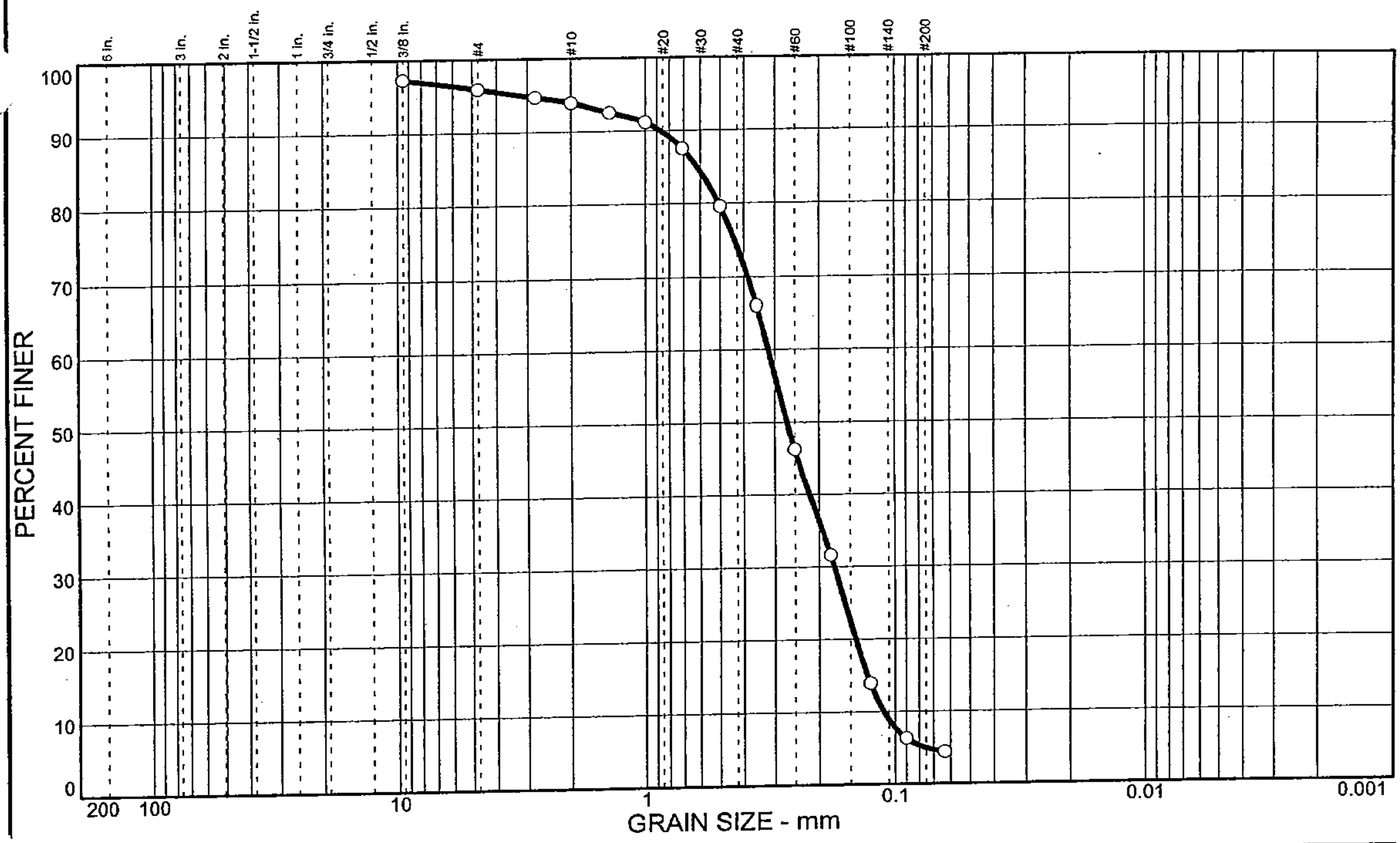
REMARKS:

O South Sand Mound Test Pits
Visual Percent Shell: 19%

O Source: TP-VKSM101-4 Sample No.: 5' Elev./Depth: +9.9'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			91.0	4.9		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	97.3		
	GRAIN SIZE		
D_{60}	0.319		
D_{30}	0.174		
D_{10}	0.111		
	COEFFICIENTS		
C_c	0.86		
C_u	2.88		

SIEVE number size	PERCENT FINER ○		
#4	95.9		
#7	94.7		
#10	93.9		
#14	92.5		
#18	91.1		
#25	87.5		
#35	79.6		
#45	66.0		
#60	46.2		
#80	31.6		
#120	13.9		
#170	6.3		
#230	4.4		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some medium to fine sand sized shell fragments, brown

REMARKS:

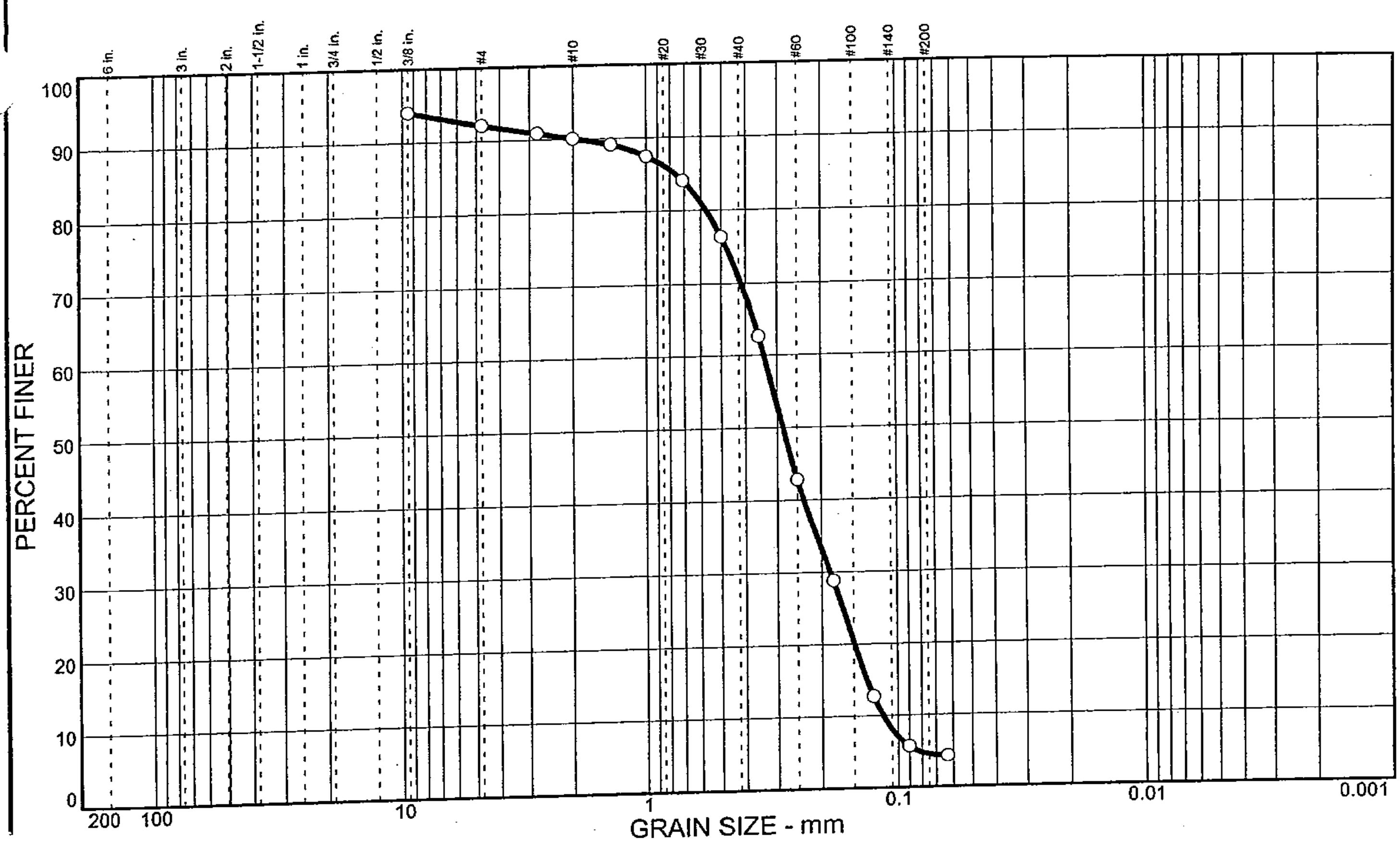
○ North Sand Mound Test Pits
Visual Percent Shell: 50%

○ Source: TP-VKSM201-1 Sample No.: 2' Elev./Depth: +11.2'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			87.5	4.6		SP	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	94.0		
	GRAIN SIZE		
D_{60}	0.338		
D_{30}	0.185		
D_{10}	0.115		
	COEFFICIENTS		
C_c	0.88		
C_u	2.95		

SIEVE number size	PERCENT FINER O		
#4	92.1		
#7	90.9		
#10	90.1		
#14	89.2		
#18	87.5		
#25	84.1		
#35	76.4		
#45	62.6		
#60	42.8		
#80	28.8		
#120	12.7		
#170	5.7		
#230	4.3		

SOIL DESCRIPTION
O SAND, medium to fine quartz, some course to fine sand sixed shell fragments, brown

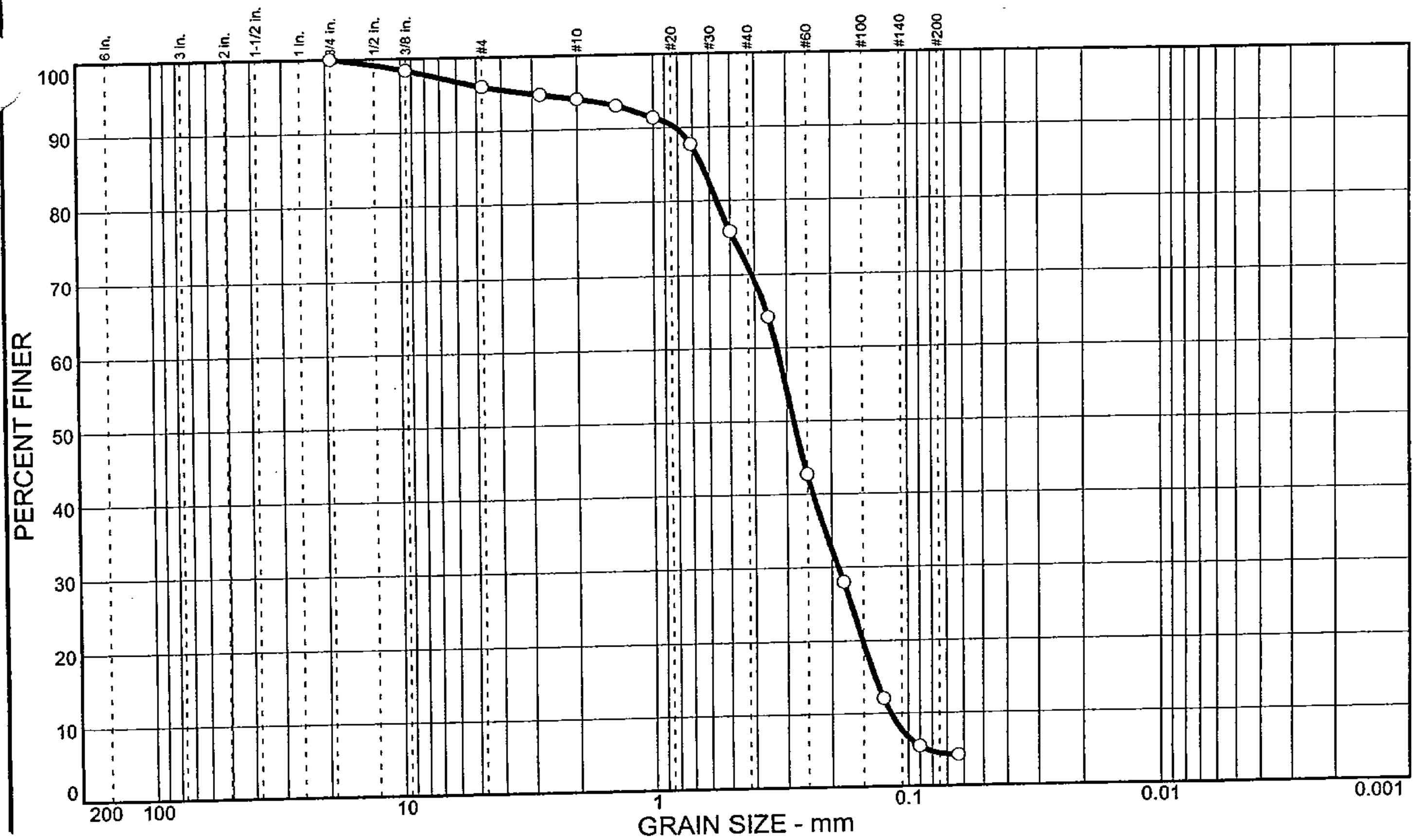
REMARKS:
O North Sand Mound Test Pits
Visual Percent Shell: 58%

O Source: TP-VKSM201-1 Sample No.: 4' Elev./Depth: +13.2'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		4.0	91.5	4.5		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
3/4	100.0		
3/8	98.4		
	GRAIN SIZE		
D_{60}	0.329		
D_{30}	0.189		
D_{10}	0.117		
	COEFFICIENTS		
C_c	0.93		
C_u	2.82		

SIEVE number size	PERCENT FINER ○		
#4	96.0		
#7	94.8		
#10	94.1		
#14	93.1		
#18	91.4		
#25	87.7		
#35	75.9		
#45	64.2		
#60	42.7		
#80	28.0		
#120	12.1		
#170	5.5		
#230	4.2		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some course to fine sand sized shell fragments, brown

REMARKS:

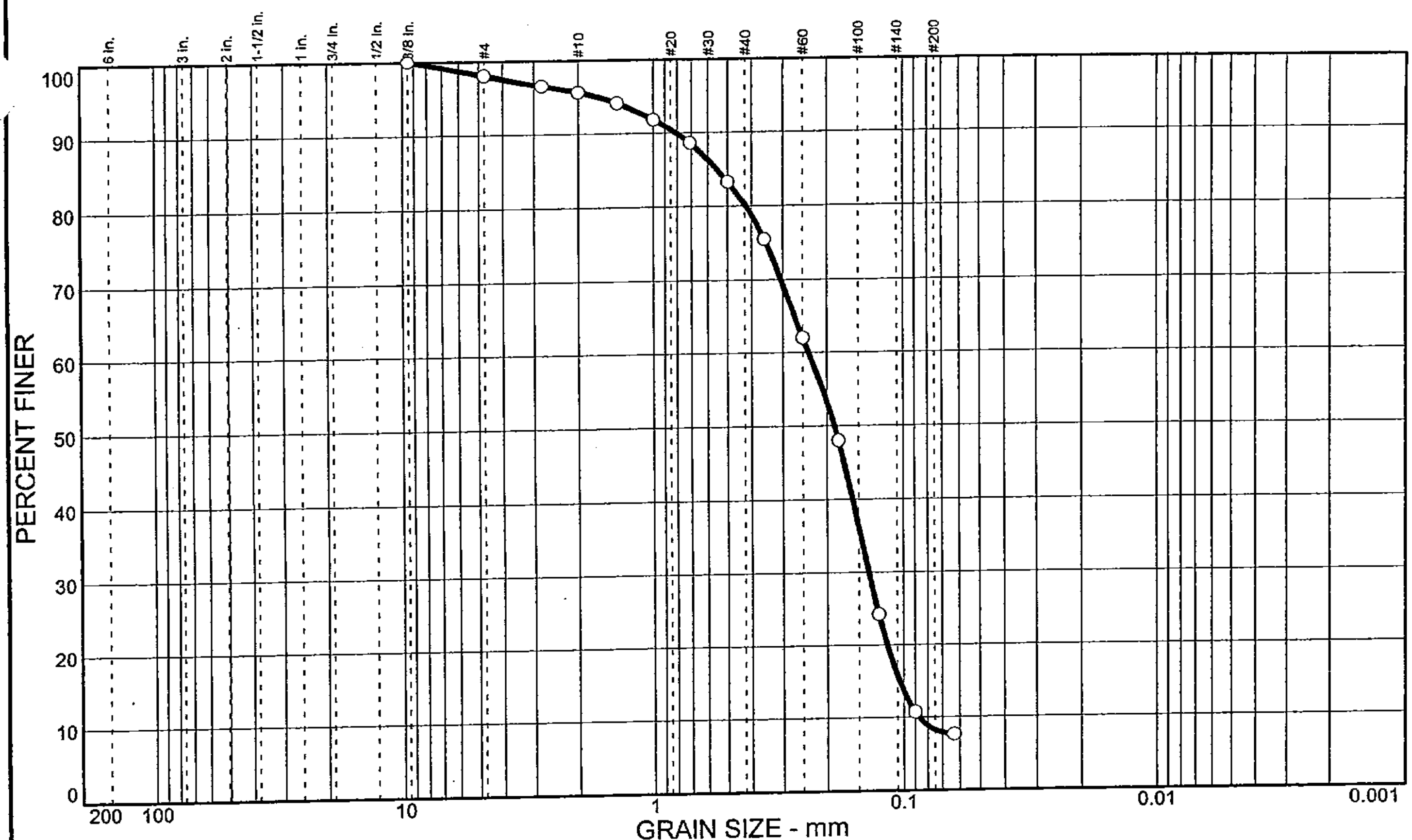
○ North Sand Mound Test Pits
Visual Percent Shell: 37%

○ Source: TP-VKSM201-1 Sample No.: 8' Elev./Depth: +17.2'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.0	89.8	8.2		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.237		
D_{30}	0.137		
D_{10}	0.0870		
	COEFFICIENTS		
C_c	0.91		
C_u	2.73		

SIEVE number size	PERCENT FINER O		
#4	98.0		
#7	96.5		
#10	95.6		
#14	94.1		
#18	91.8		
#25	88.6		
#35	83.3		
#45	75.5		
#60	62.0		
#80	48.0		
#120	24.2		
#170	10.7		
#230	7.6		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some sand sized shell fragments, trace silt, light brown-brown

REMARKS:

O North Sand Mound Test Pits
Visual Percent Shell: 27%

O Source: TP-VKSM201-2

Sample No.: 2'

Elev./Depth: +6.9'

Law Engineering and Environmental Services, Inc.

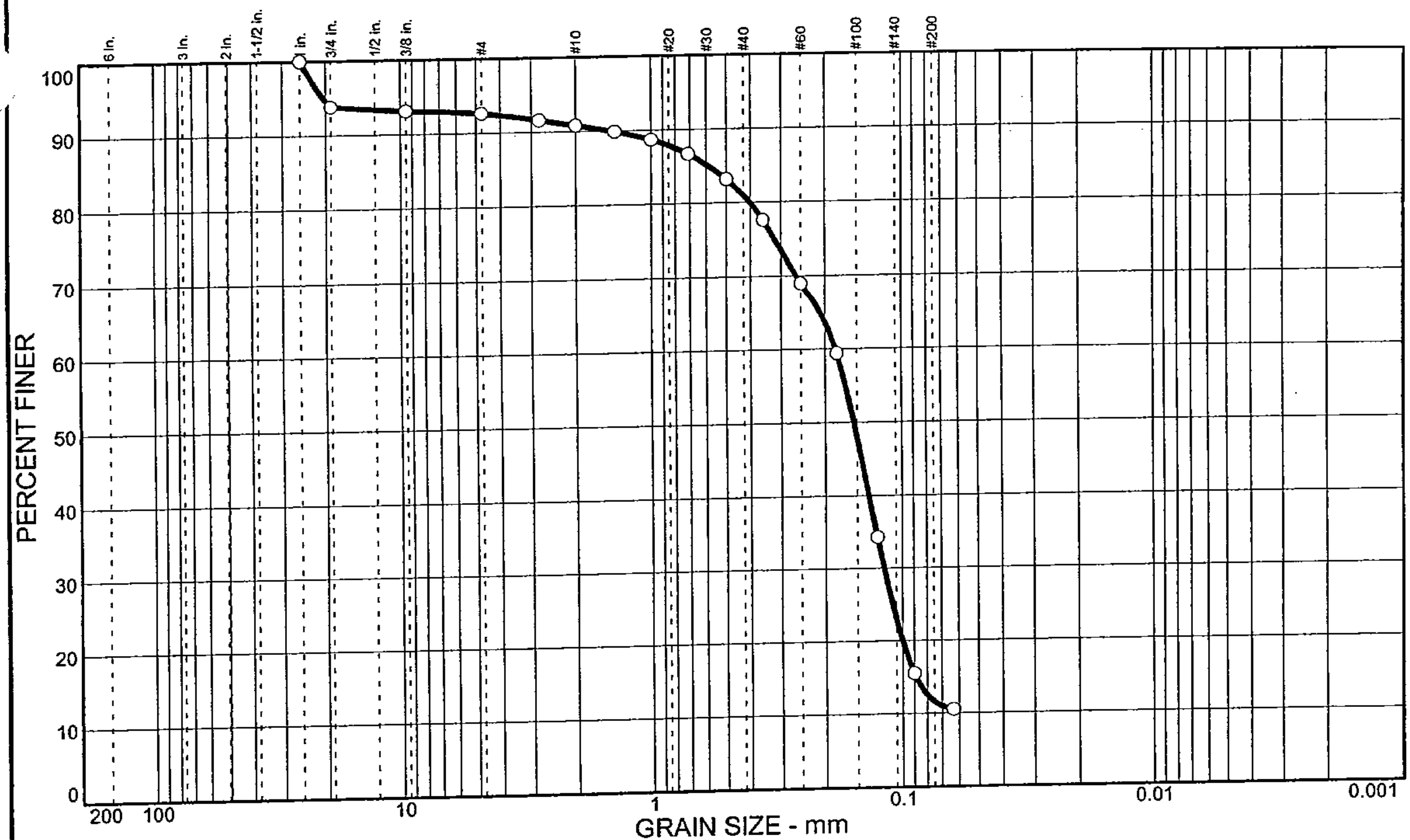
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		7.4	81.0	11.6		SP-SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
1	100.0		
3/4	93.8		
3/8	93.1		
	GRAIN SIZE		
D_{60}	0.182		
D_{30}	0.118		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	92.6		
#7	91.6		
#10	90.8		
#14	89.9		
#18	88.7		
#25	86.7		
#35	83.2		
#45	77.6		
#60	69.0		
#80	59.4		
#120	34.2		
#170	15.5		
#230	10.5		

SOIL DESCRIPTION

○ SAND, fine quartz, some course to fine sand sized shell fragments, trace limestone fragments, little silt, light brown

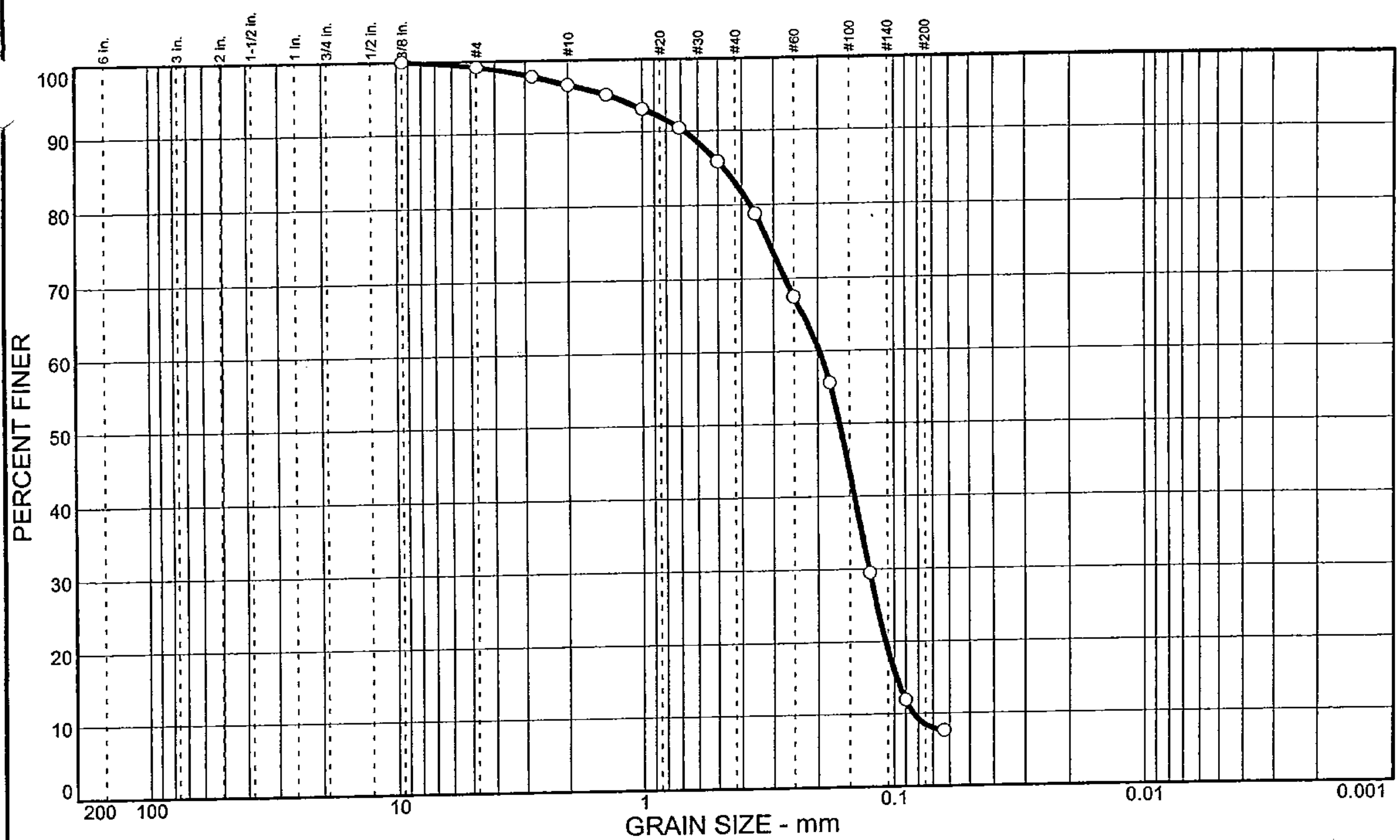
REMARKS:

○ North Sand Mound Test Pits
Visual Percent Shell: 46%

○ Source: TP-VKSM201-2 Sample No.: 6' Elev./Depth: +10.9'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.9	90.7	8.4		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.198		
D_{30}	0.126		
D_{10}	0.0836		
	COEFFICIENTS		
C_c	0.96		
C_u	2.37		

SIEVE number size	PERCENT FINER ○		
#4	99.1		
#7	97.7		
#10	96.5		
#14	95.1		
#18	93.1		
#25	90.5		
#35	85.9		
#45	78.8		
#60	67.5		
#80	55.6		
#120	29.5		
#170	11.9		
#230	7.6		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, little sand sized shell fragments, trace silt, light brown-brown

REMARKS:

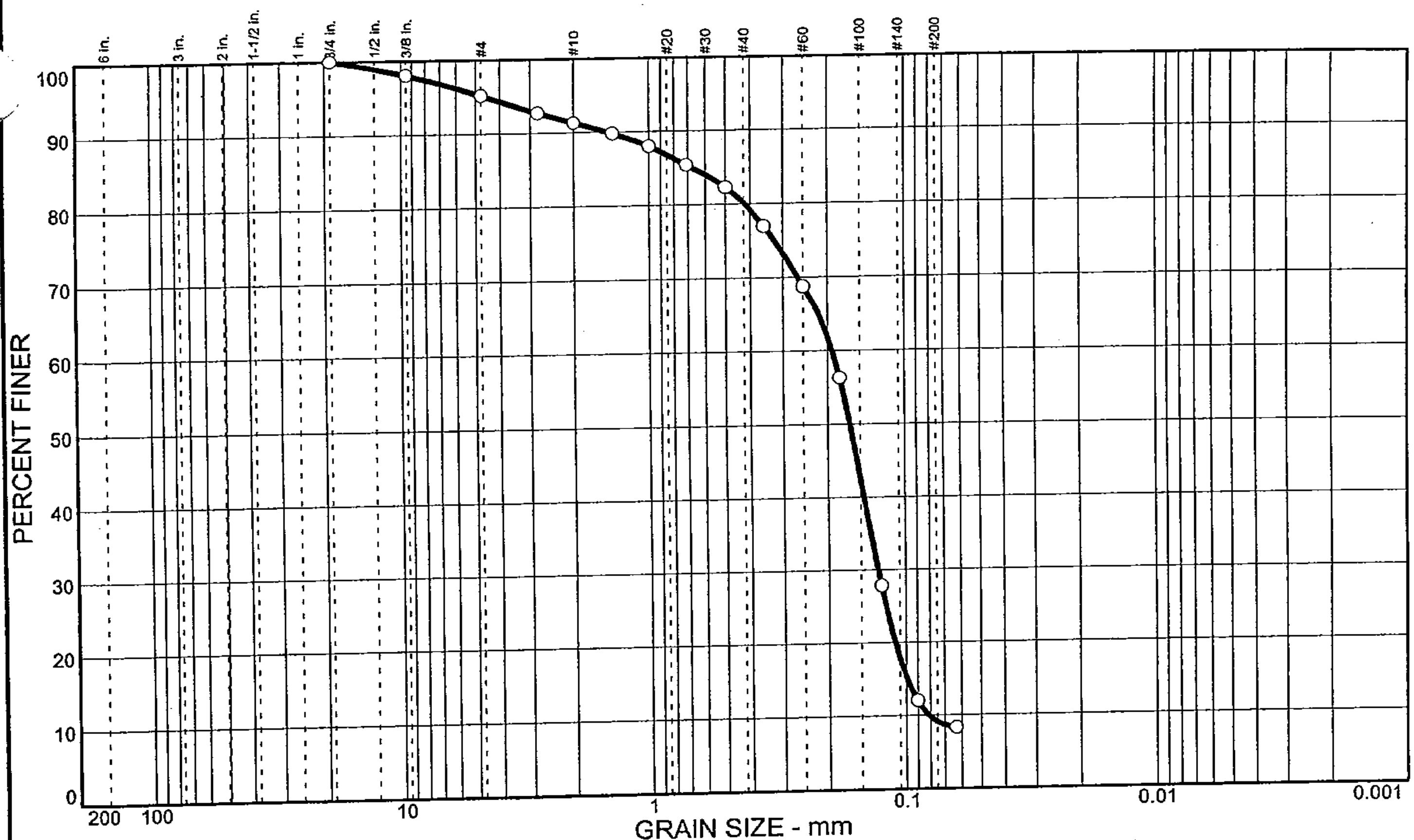
○ North Sand Mound Test Pits
Visual Percent Shell: 27%

○ Source: TP-VKSM201-2 Sample No.: 9' Elev./Depth: +13.9'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		4.9	86.0	9.1		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/4	100.0		
3/8	98.0		
	GRAIN SIZE		
D_{60}	0.193		
D_{30}	0.129		
D_{10}	0.0813		
	COEFFICIENTS		
C_c	1.06		
C_u	2.37		

SIEVE number size	PERCENT FINER ○		
#4	95.1		
#7	92.7		
#10	91.3		
#14	89.8		
#18	88.0		
#25	85.4		
#35	82.3		
#45	77.0		
#60	68.8		
#80	56.3		
#120	27.8		
#170	12.0		
#230	8.3		

SOIL DESCRIPTION
○ SAND, medium to fine quartz, some sand sized shell fragments, trace silt, brown

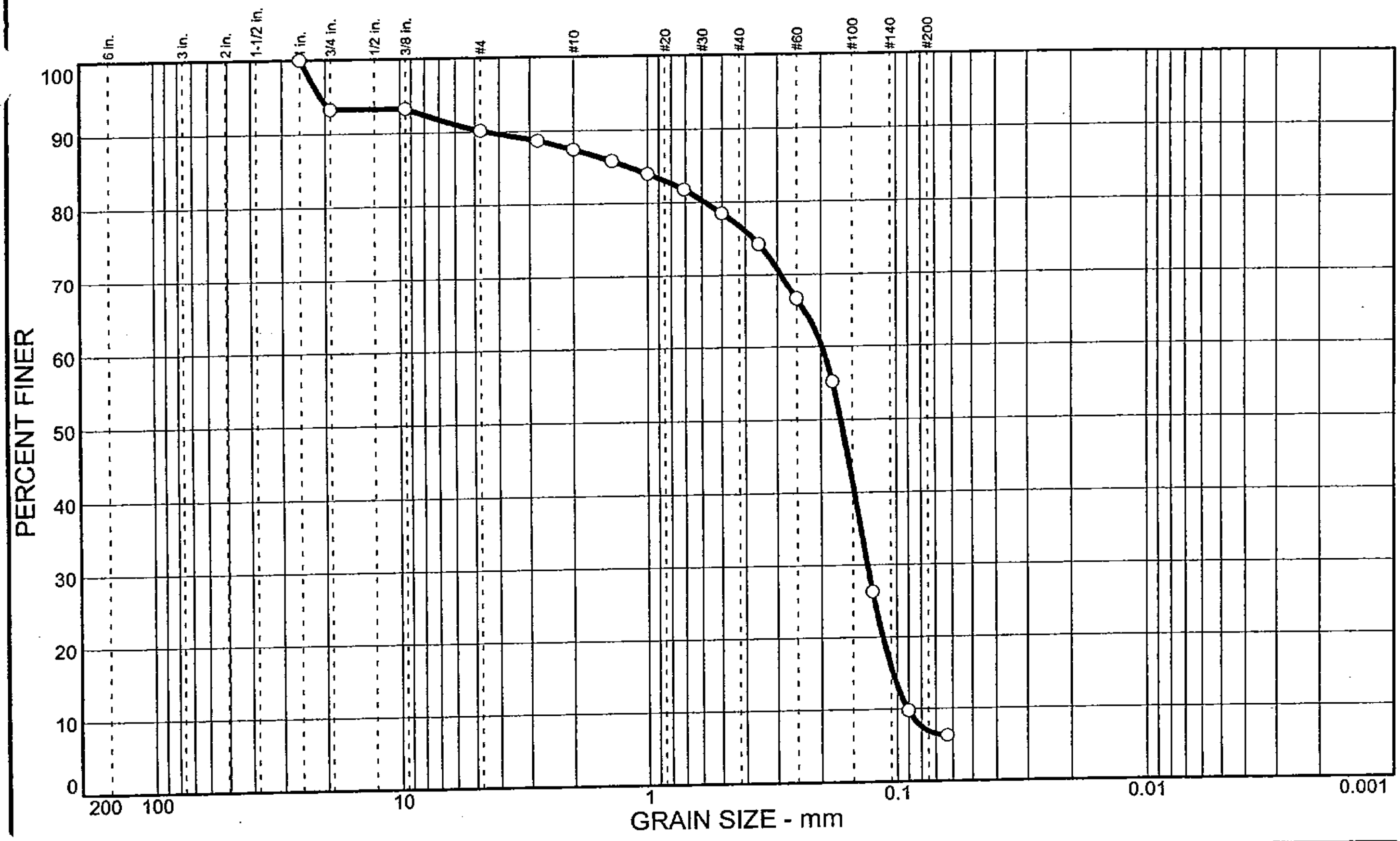
REMARKS:
○ North Sand Mound Test Pits
Visual Percent Shell: 30%

○ Source: TP-VKSM201-3 Sample No.: 2' Elev./Depth: +6.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		9.8	83.3	6.9		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
1	100.0		
3/4	93.3		
3/8	93.3		
	GRAIN SIZE		
D_{60}	0.198		
D_{30}	0.131		
D_{10}	0.0907		
	COEFFICIENTS		
C_c	0.96		
C_u	2.19		

SIEVE number size	PERCENT FINER ○		
#4	90.2		
#7	88.7		
#10	87.4		
#14	85.8		
#18	84.0		
#25	81.8		
#35	78.5		
#45	74.2		
#60	66.6		
#80	55.2		
#120	26.3		
#170	9.8		
#230	6.3		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some course to fine sand sized shell fragments, trace limestone fragments, trace silt, brown

REMARKS:

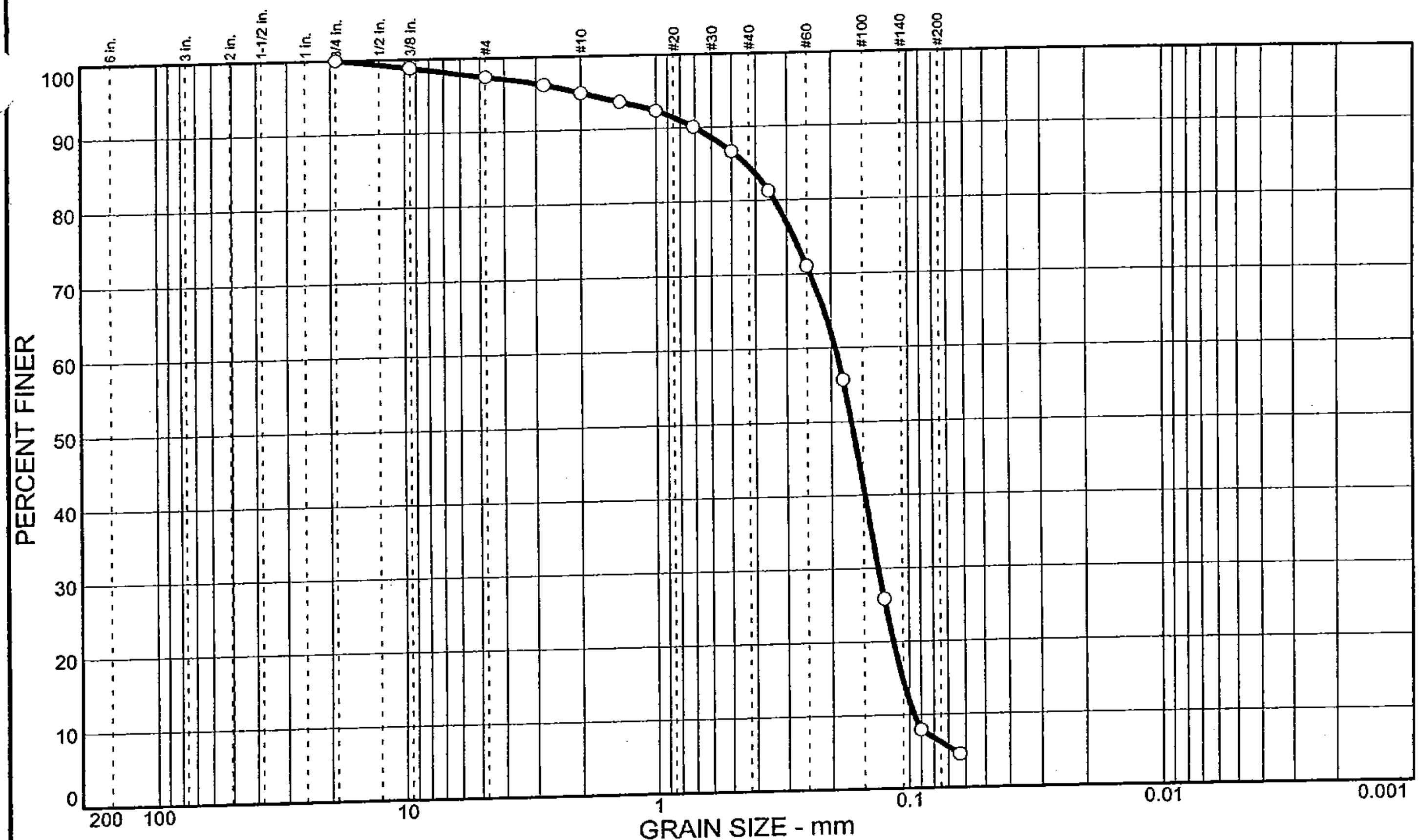
○ North Sand Mound Test Pits
Visual Percent Shell: 38%

○ Source: TP-VKSM201-3 Sample No.: 3.5' Elev./Depth: +8.3'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.6	91.2	6.2		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/4	100.0		
3/8	98.8		
	GRAIN SIZE		
D_{60}	0.193		
D_{30}	0.132		
D_{10}	0.0957		
	COEFFICIENTS		
C_c	0.94		
C_u	2.02		

SIEVE number size	PERCENT FINER O		
#4	97.4		
#7	96.2		
#10	95.0		
#14	93.7		
#18	92.4		
#25	90.1		
#35	86.7		
#45	81.3		
#60	71.1		
#80	55.7		
#120	25.8		
#170	7.9		
#230	4.5		

SOIL DESCRIPTION

O SAND, medium to fine quartz, little sand sized shell fragments, trace silt, light brown and tan

REMARKS:

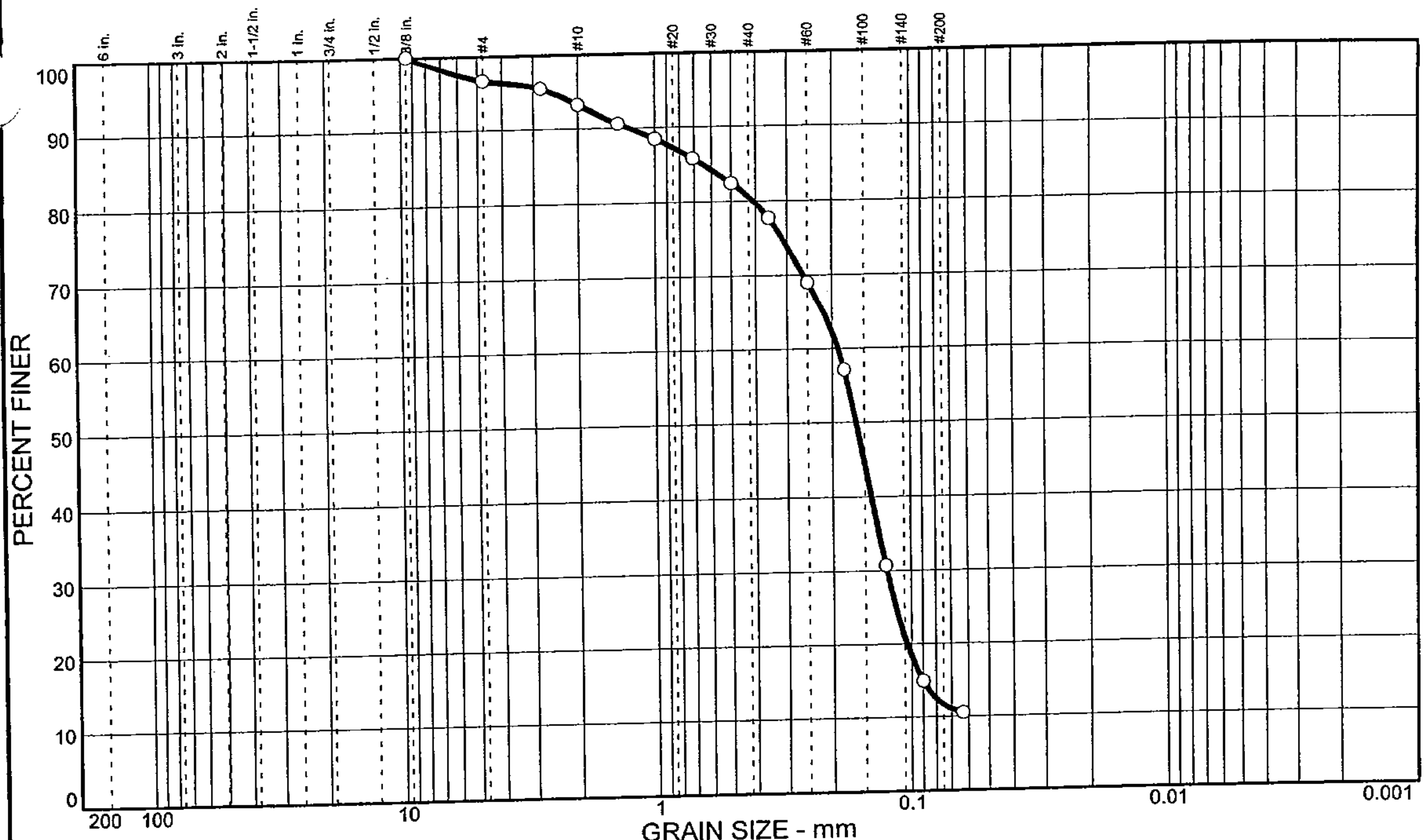
O North Sand Mound Test Pits
Visual Percent Shell: 32%

O Source: TP-VKSM201-3 Sample No.: 5' Elev./Depth: +9.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		3.4	85.0	11.6		SP-SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.190		
D_{30}	0.124		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER O		
#4	96.6		
#7	95.4		
#10	93.2		
#14	90.6		
#18	88.5		
#25	85.8		
#35	82.4		
#45	77.7		
#60	69.0		
#80	57.1		
#120	30.7		
#170	14.9		
#230	10.5		

SOIL DESCRIPTION

O SAND, medium to fine quartz, little sand sized shell fragments, little silt, light brown and dark brown

REMARKS:

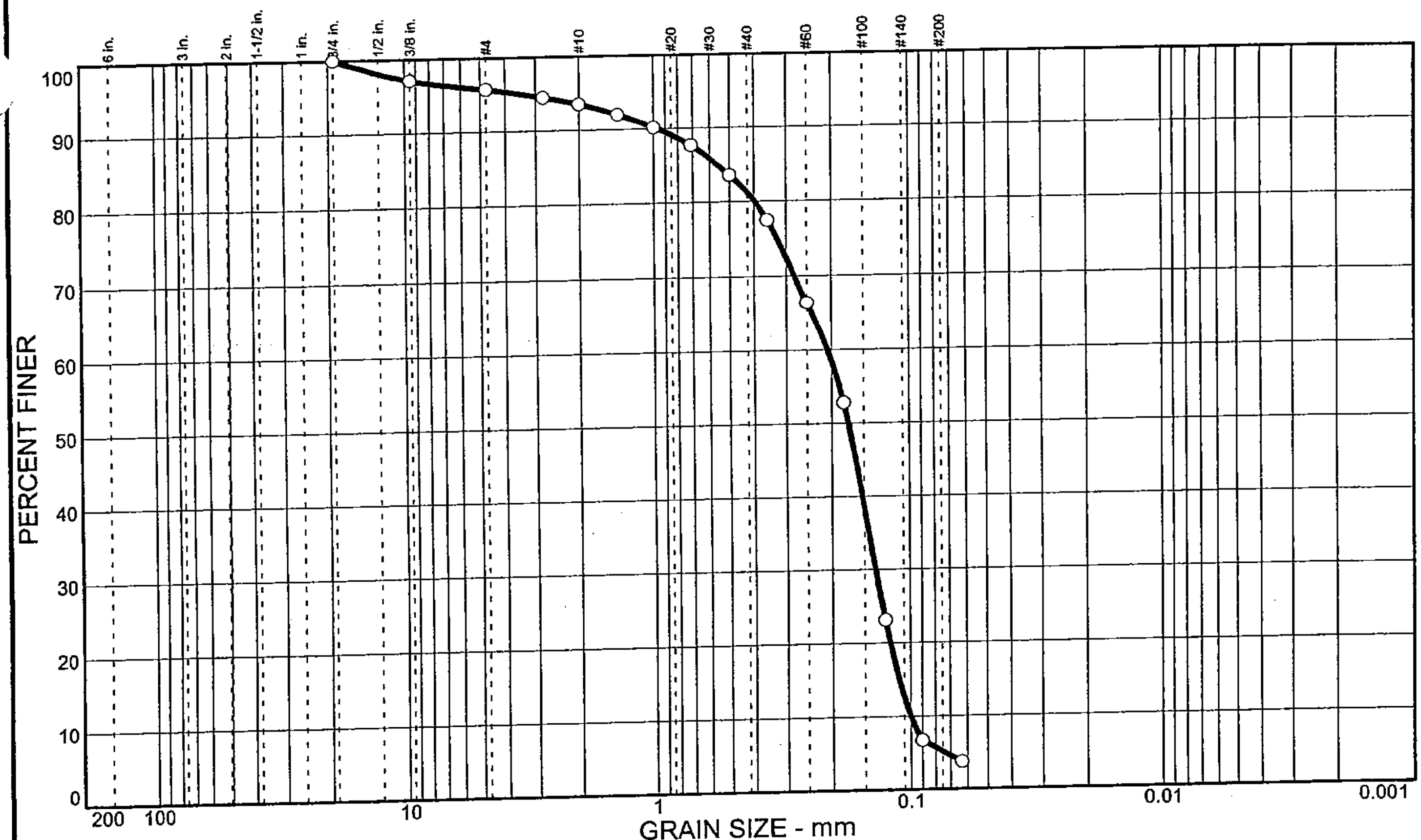
O North Sand Mound Test Pits
Visual Percent Shell: 17%

O Source: TP-VKSM201-4 Sample No.: 2' Elev./Depth: +8.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		4.3	90.5	5.2		SP-SM	A-3		

SIEVE inches size	PERCENT FINER O		
3/4	100.0		
3/8	97.1		
	GRAIN SIZE		
D_{60}	0.208		
D_{30}	0.136		
D_{10}	0.0996		
	COEFFICIENTS		
C_c	0.90		
C_u	2.08		

SIEVE number size	PERCENT FINER O		
#4	95.7		
#7	94.5		
#10	93.5		
#14	92.0		
#18	90.2		
#25	87.7		
#35	83.6		
#45	77.5		
#60	66.3		
#80	52.8		
#120	23.1		
#170	6.7		
#230	3.7		

SOIL DESCRIPTION

O SAND, medium to fine quartz, some sand size shell fragments, trace silt, light brown

REMARKS:

O North Sand Mound Test Pits
Visual Percent Shell: 29%

O Source: TP-VKSM201-4

Sample No.: 5'

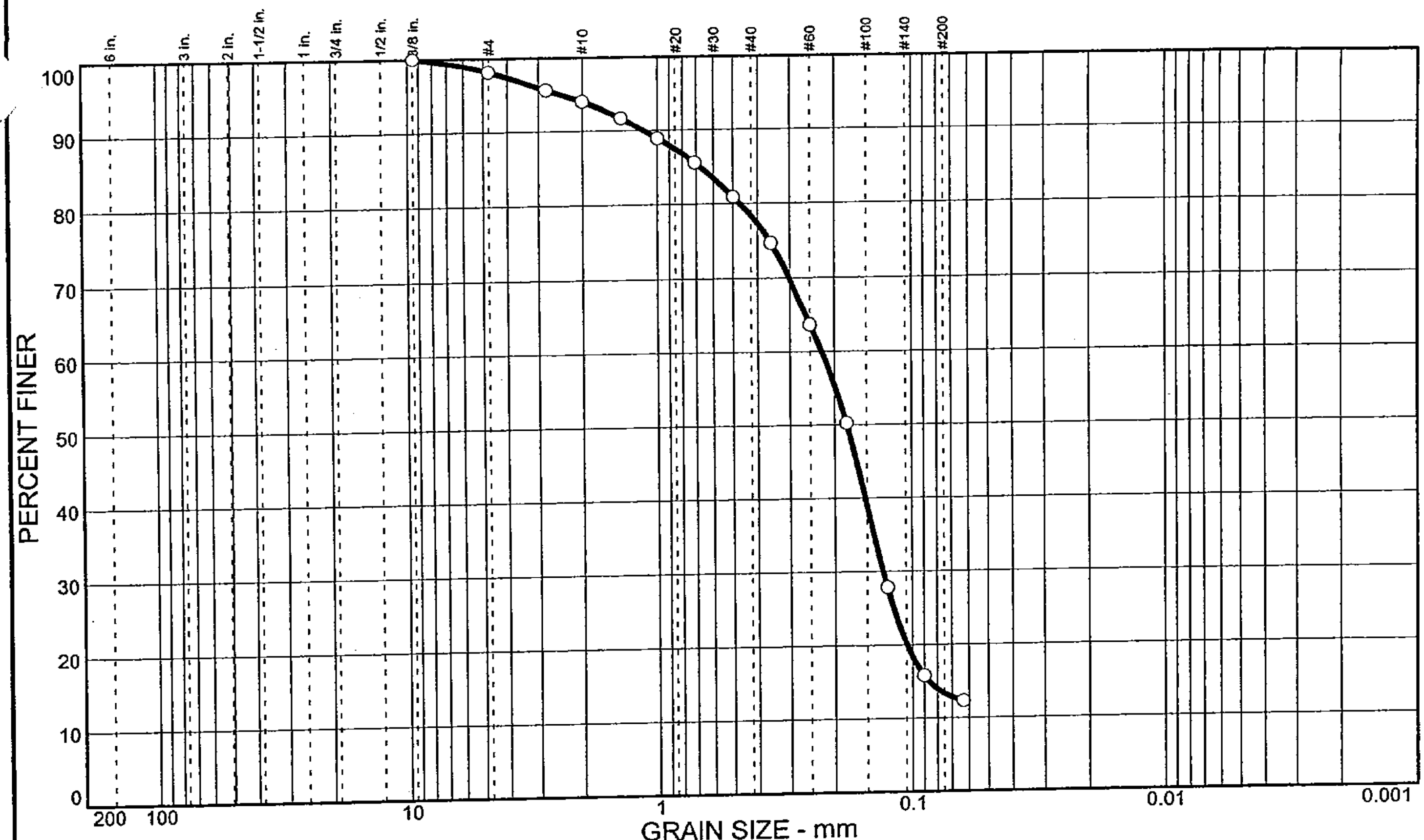
Elev./Depth: +11.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		1.9	84.8	13.3		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.226		
D_{30}	0.130		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

O Source: TP-VKSM201-4

SIEVE number size	PERCENT FINER O		
#4	98.1		
#7	95.6		
#10	94.0		
#14	91.7		
#18	88.9		
#25	85.6		
#35	80.9		
#45	74.7		
#60	63.6		
#80	50.2		
#120	27.8		
#170	15.8		
#230	12.3		

Sample No.: 7'

SOIL DESCRIPTION

O SAND, medium to fine quartz, little sand sized shell fragments, little silt, trace sand sized limestone fragments, dark brown-gray

REMARKS:

O North Sand Mound Test Pits
Visual Percent Shell: 13%

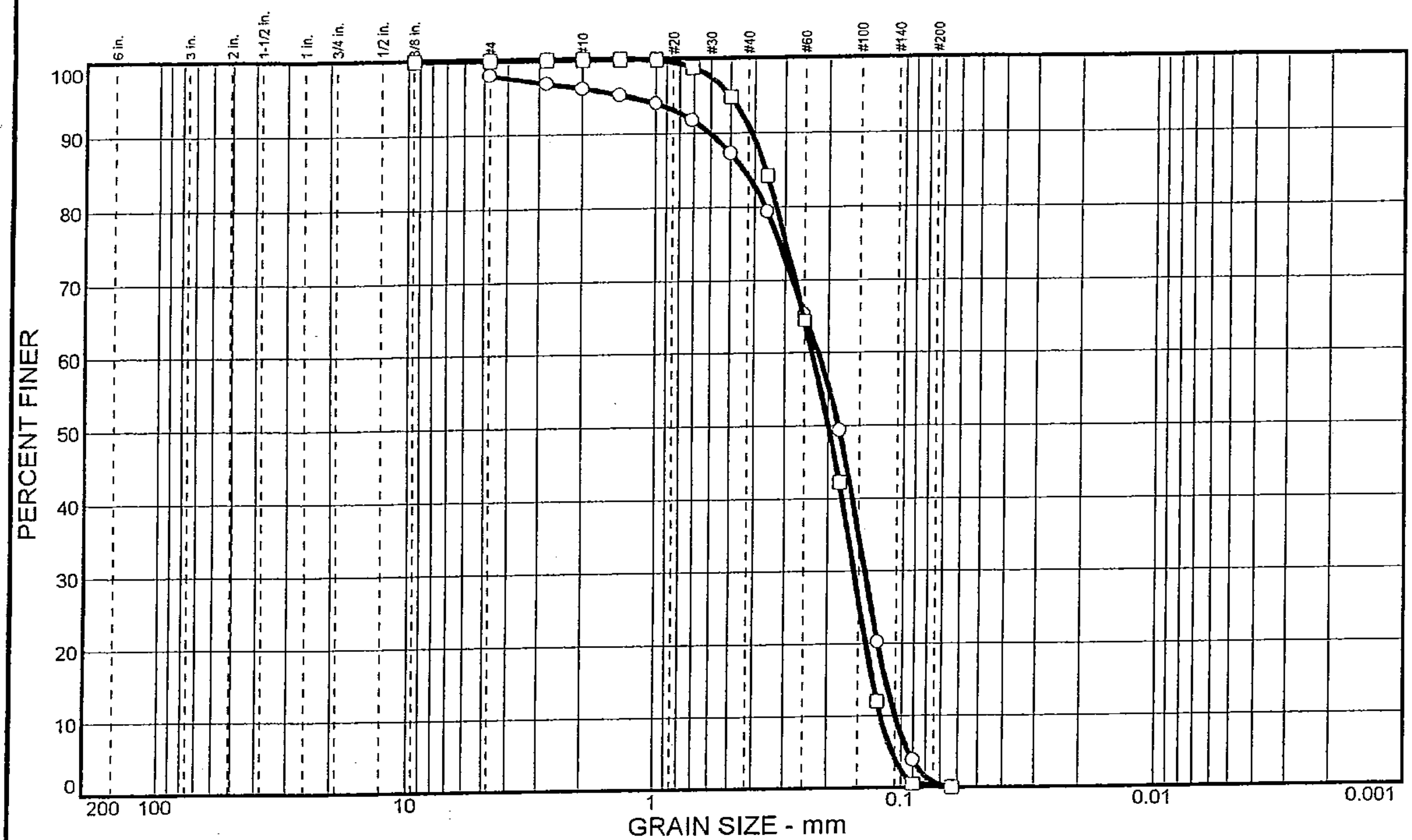
Elev./Depth: +13.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			97.2	0.8		SP	A-3		
□			99.8	0.2	0.0	SP	A-3		

SIEVE inches size	PERCENT FINER ○	□	
3/8		100.0	
	GRAIN SIZE		
D_{60}	0.220	0.232	
D_{30}	0.141	0.156	
D_{10}	0.106	0.121	
	COEFFICIENTS		
C_c	0.86	0.87	
C_u	2.07	1.92	

SIEVE number size	PERCENT FINER ○	□	
#4	98.0	100.0	
#7	96.8	100.0	
#10	96.1	100.0	
#14	95.2	100.0	
#18	94.0	99.9	
#25	91.7	98.9	
#35	87.2	94.9	
#45	79.3	84.2	
#60	65.4	64.5	
#80	49.4	42.3	
#120	20.2	12.0	
#170	3.8	0.5	
#230	0.1	0.0	

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, light brown

□ SAND, medium to fine quartz, light gray, little fine sand sized shell fragments

REMARKS:

○ COMPOSITE SAMPLE OF TP-VKSM101-1, 2,3,4 Percent Carbonate: 53.01%
Percent Visual Shell: 28.0%

□ Composite Sample for TP-VKSM101-1,2,3,4

○ Source: TP-VKSM101 Sample No.: Pre-Acid Sample

□ Source: TP-VKSM101 Sample No.: Post-Acid Sample

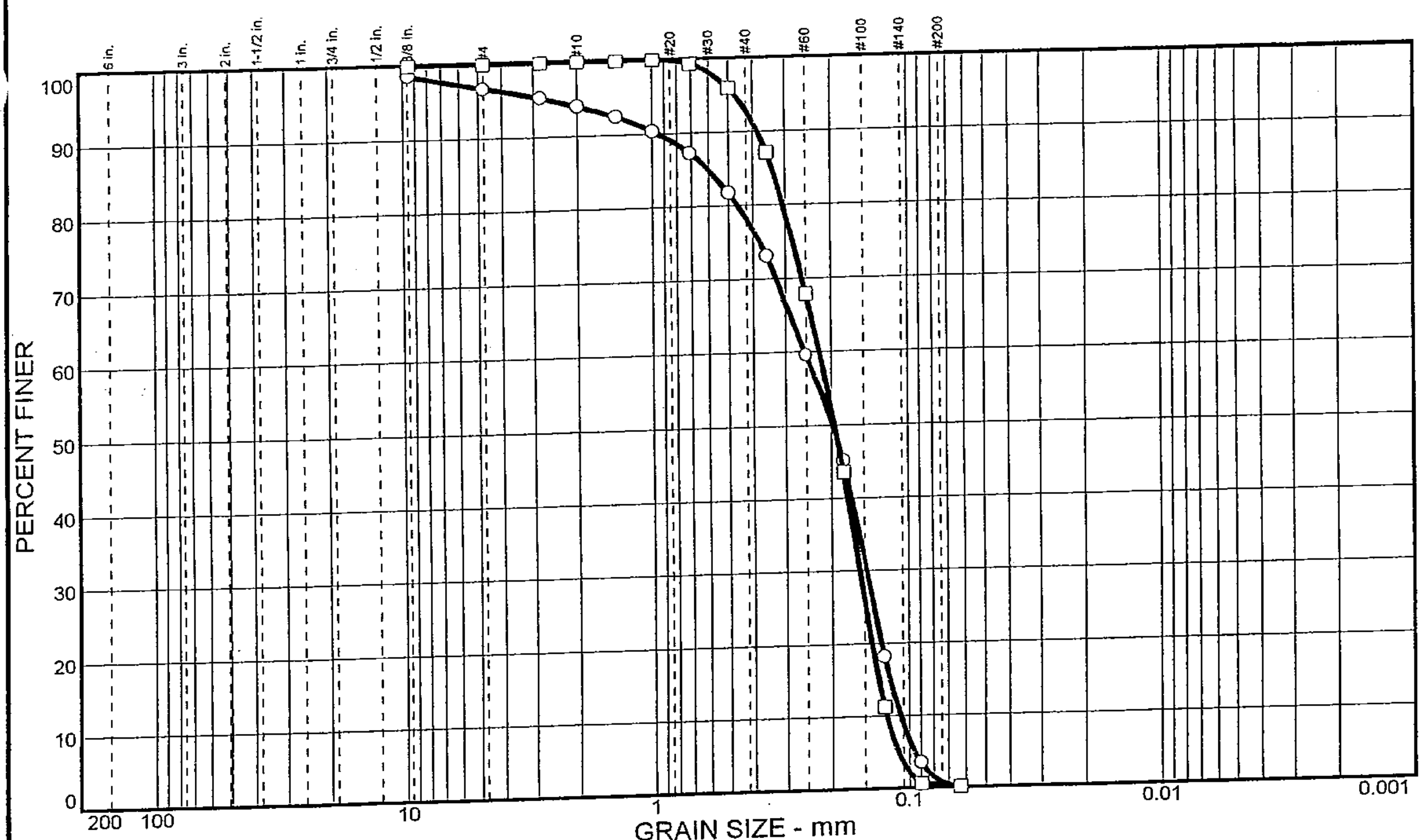
Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			95.9	0.8		SP	A-3		
□			99.7	0.3		SP	A-3		

SIEVE inches size	PERCENT FINER ○	PERCENT FINER □	
3/8	98.6	100.0	
	GRAIN SIZE		
D_{60}	0.253	0.222	
D_{30}	0.147	0.156	
D_{10}	0.108	0.123	
	COEFFICIENTS		
C_c	0.78	0.89	
C_u	2.34	1.81	

SIEVE number size	PERCENT FINER ○	PERCENT FINER □	
#4	96.7	100.0	
#7	95.2	100.0	
#10	93.9	100.0	
#14	92.4	100.0	
#18	90.3	100.0	
#25	87.2	99.3	
#35	81.7	96.0	
#45	73.0	87.1	
#60	59.5	67.9	
#80	45.1	43.6	
#120	18.1	11.2	
#170	3.5	0.6	
#230	0.1	0.1	

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, light brown

□ SAND, medium to fine quartz, little sand sized shell fragments, light gray

REMARKS:

○ COMPOSITE SAMPLE OF TP-VKSM102-1, 2,3,4 Percent Carbonate: 64.0% Percent Visual Shell: 39.0%

□ Composite Sample for TP-VKSM102-1,2,3,4

○ Source: TP-VKSM201 Sample No.: Pre-Acid Sample

□ Source: TP-VKSM201 Sample No.: Post-Acid Sample

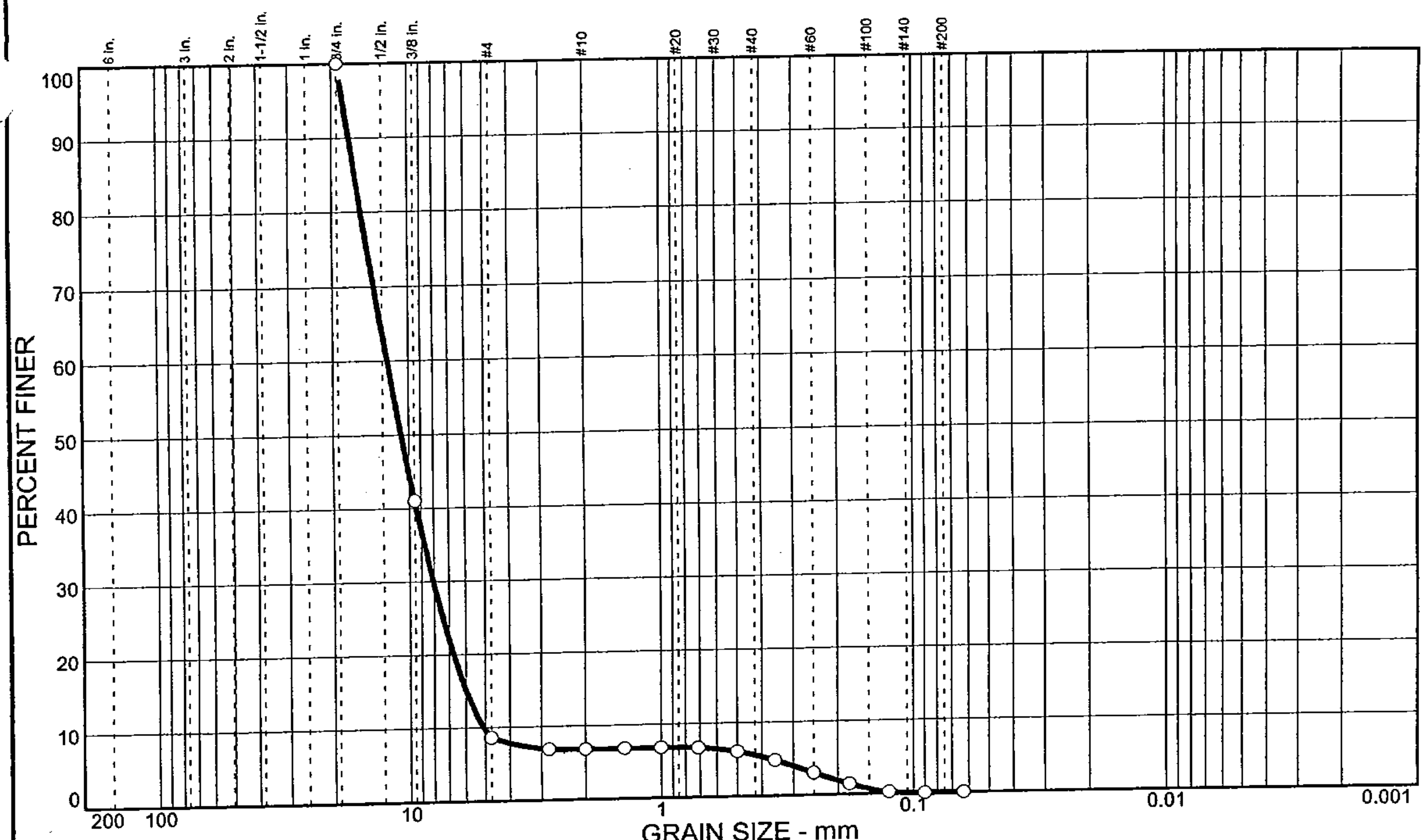
Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		91.4	8.6	0.0	0.0	GP	A-1-a		

SIEVE inches size	PERCENT FINER ○		
3/4	100.0		
3/8	41.0		
	GRAIN SIZE		
D_{60}	12.2		
D_{30}	8.06		
D_{10}	5.08		
	COEFFICIENTS		
C_c	1.05		
C_u	2.40		

○ Source: P/L-VK01-1

SIEVE number size	PERCENT FINER ○		
#4	8.6		
#7	6.9		
#10	6.8		
#14	6.8		
#18	6.8		
#25	6.7		
#35	6.1		
#45	4.8		
#60	3.0		
#80	1.4		
#120	0.2		
#170	0.0		
#230	0.0		

Sample No.: A

SOIL DESCRIPTION

○ GRAVEL, trace fine quartz sand, brown-gray and orange

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 0.0%

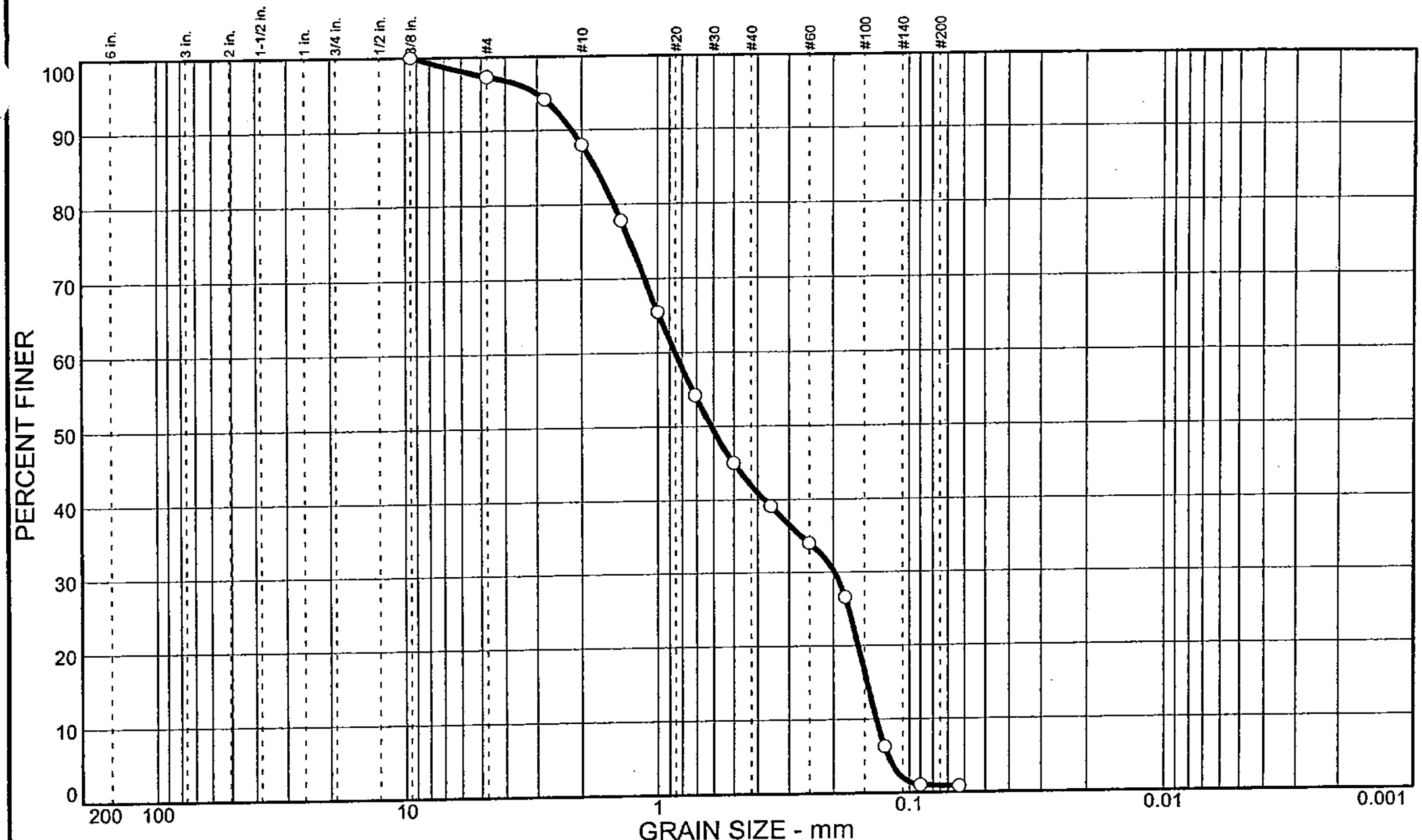
Elev./Depth: +2.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		2.7	96.4	0.9		SP	A-1-b		

SIEVE inches size	PERCENT FINER O		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.855		
D_{30}	0.198		
D_{10}	0.135		
	COEFFICIENTS		
C_c	0.34		
C_u	6.34		

SIEVE number size	PERCENT FINER O		
#4	97.3		
#7	94.2		
#10	88.0		
#14	77.8		
#18	65.4		
#25	54.2		
#35	45.0		
#45	39.1		
#60	34.0		
#80	26.6		
#120	6.3		
#170	1.0		
#230	0.8		

SOIL DESCRIPTION

O SAND, medium to fine sand, little sand sized sandstone, trace sand sized shell fragments, gray and brown

REMARKS:

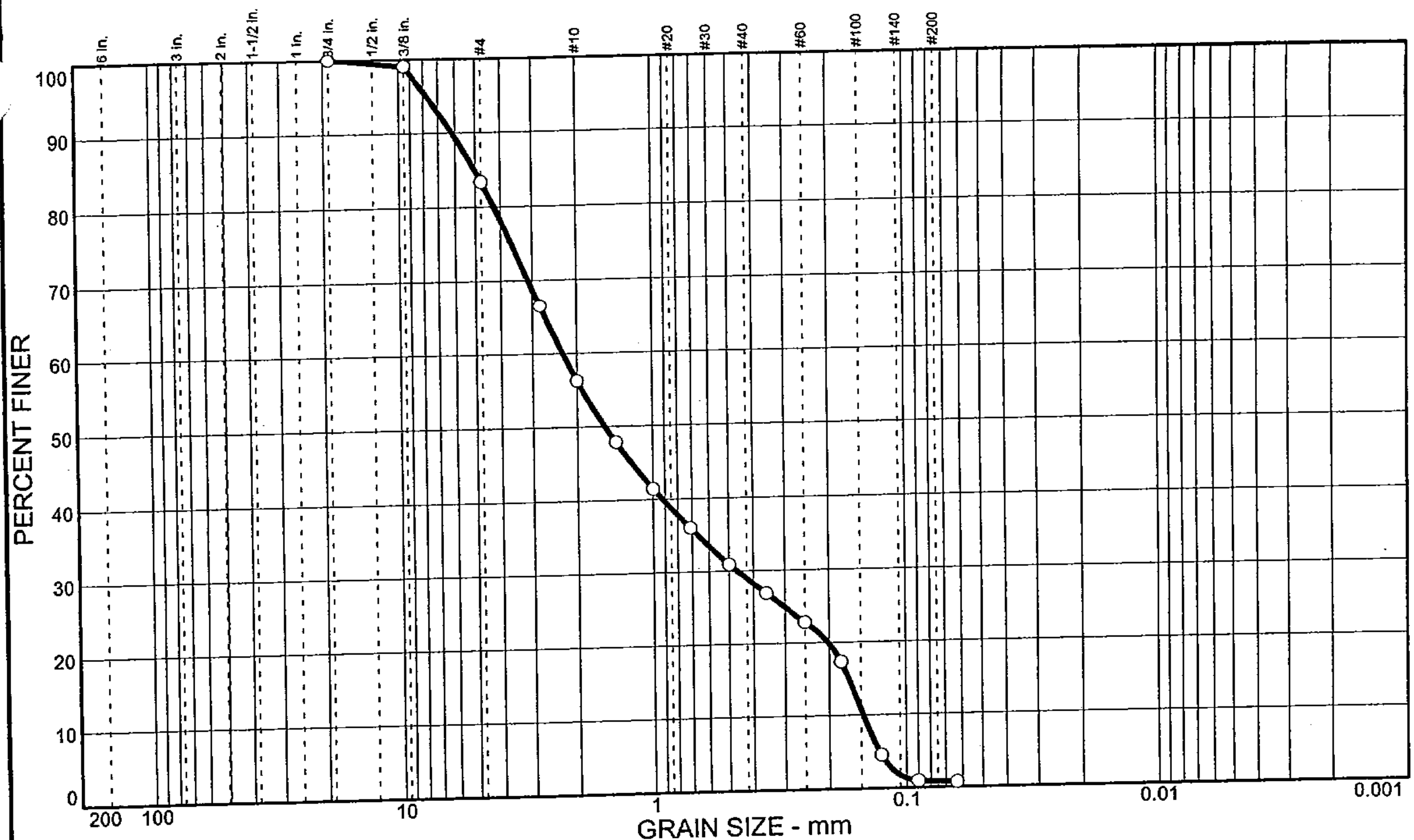
O 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 12%

O Source: P/L-VK01-1 Sample No.: B Elev./Depth: -0.6 feet

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O		16.6	82.6	0.8		SP	A-1-b		

SIEVE inches size	PERCENT FINER O		
3/4	100.0		
3/8	99.0		
	GRAIN SIZE		
D_{60}	2.28		
D_{30}	0.465		
D_{10}	0.147		
	COEFFICIENTS		
C_c	0.65		
C_u	15.52		

SIEVE number size	PERCENT FINER O		
#4	83.4		
#7	66.5		
#10	56.2		
#14	47.8		
#18	41.4		
#25	36.0		
#35	30.9		
#45	26.9		
#60	22.8		
#80	17.3		
#120	4.5		
#170	0.9		
#230	0.7		

SOIL DESCRIPTION

O SAND, course to fine quartz, little gravel size sandstone, gray and brown

REMARKS:

O 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 0.0%

O Source: P/L-VK01-1

Sample No.: C

Elev./Depth: -1.5'

Law Engineering and Environmental Services, Inc.

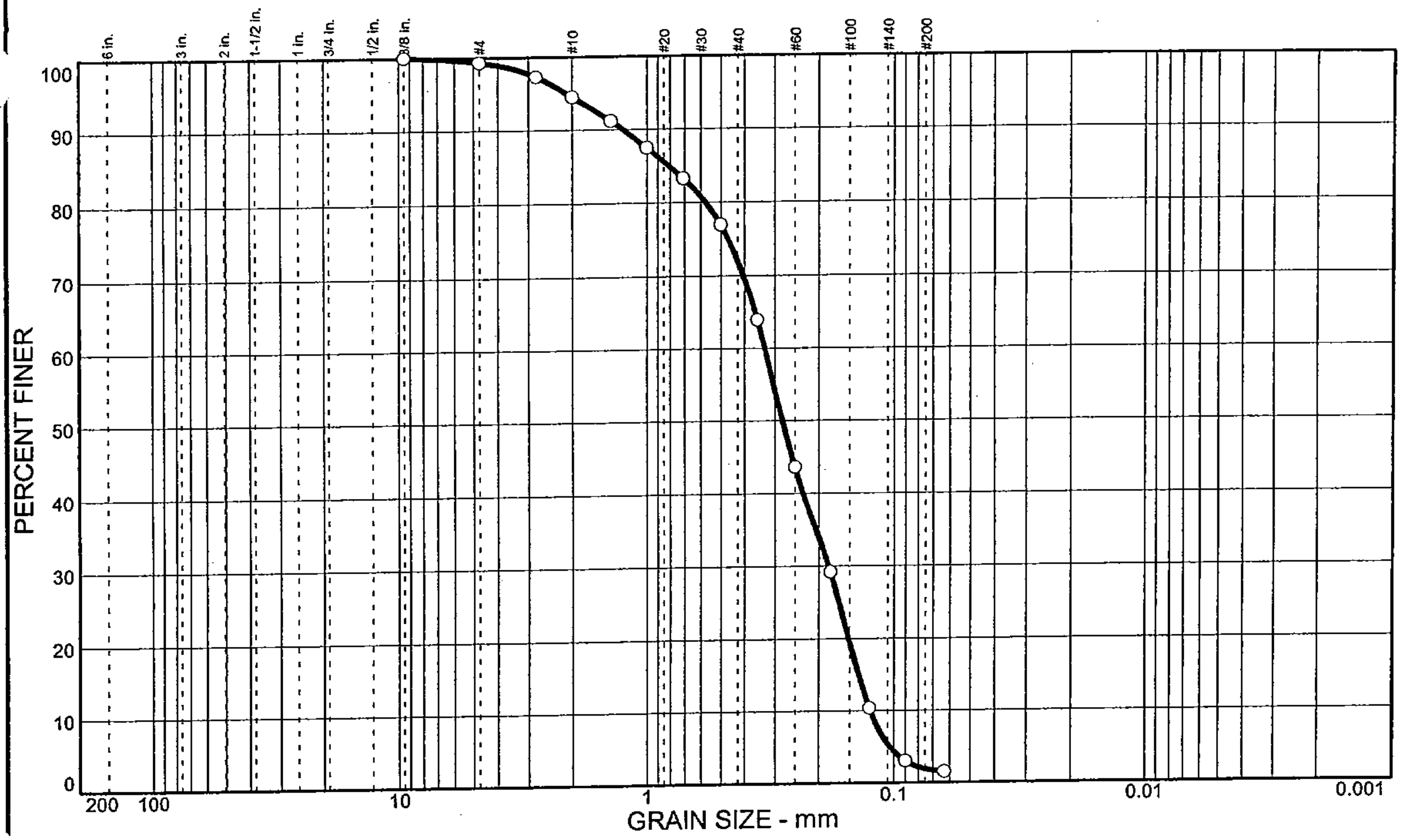
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○		0.7	97.4	1.9		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	100.0		
	GRAIN SIZE		
D_{60}	0.331		
D_{30}	0.183		
D_{10}	0.124		
	COEFFICIENTS		
C_c	0.82		
C_u	2.68		

○ Source: P/L-VK01-1

SIEVE number size	PERCENT FINER ○		
#4	99.3		
#7	97.3		
#10	94.5		
#14	91.2		
#18	87.5		
#25	83.3		
#35	77.0		
#45	63.9		
#60	43.6		
#80	29.2		
#120	10.4		
#170	3.0		
#230	1.5		

Sample No.: D

SOIL DESCRIPTION

○ SAND, medium to fine quartz, trace sand sized sandstone, gray

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 17%

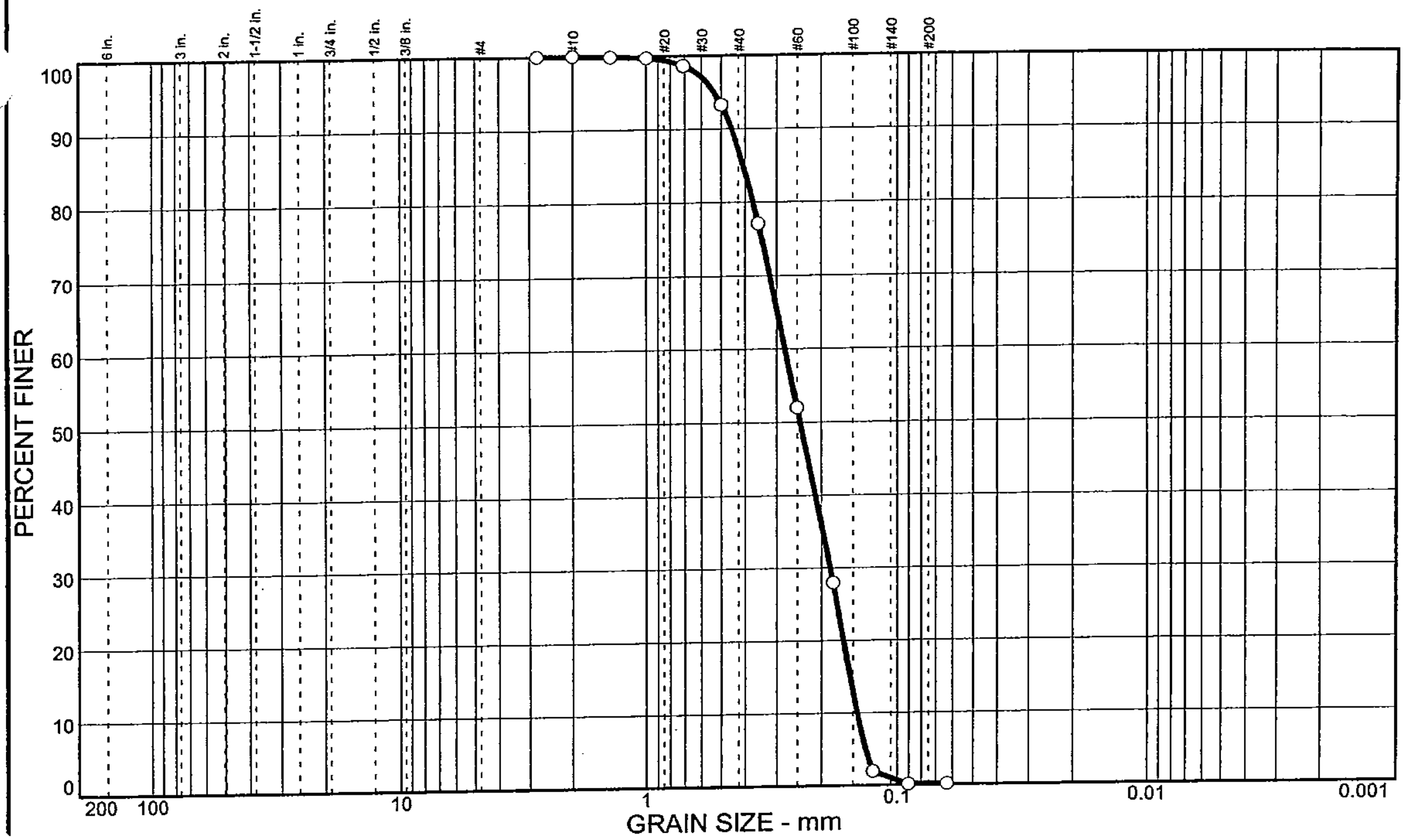
Elev./Depth: -4.1'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			99.9	0.1		SP	A-3		

SIEVE inches size	PERCENT FINER O		
	GRAIN SIZE		
D_{60}	0.279		
D_{30}	0.185		
D_{10}	0.144		
	COEFFICIENTS		
C_c	0.85		
C_u	1.93		

SIEVE number size	PERCENT FINER O		
#7	100.0		
#10	100.0		
#14	99.9		
#18	99.7		
#25	98.6		
#35	93.3		
#45	77.1		
#60	52.0		
#80	27.9		
#120	1.9		
#170	0.1		
#230	0.1		

SOIL DESCRIPTION

O SAND, fine quartz, light brown-tan

REMARKS:

O 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 0.0%

O Source: P/L-VK01-2 Sample No.: A Elev./Depth: +2.2'

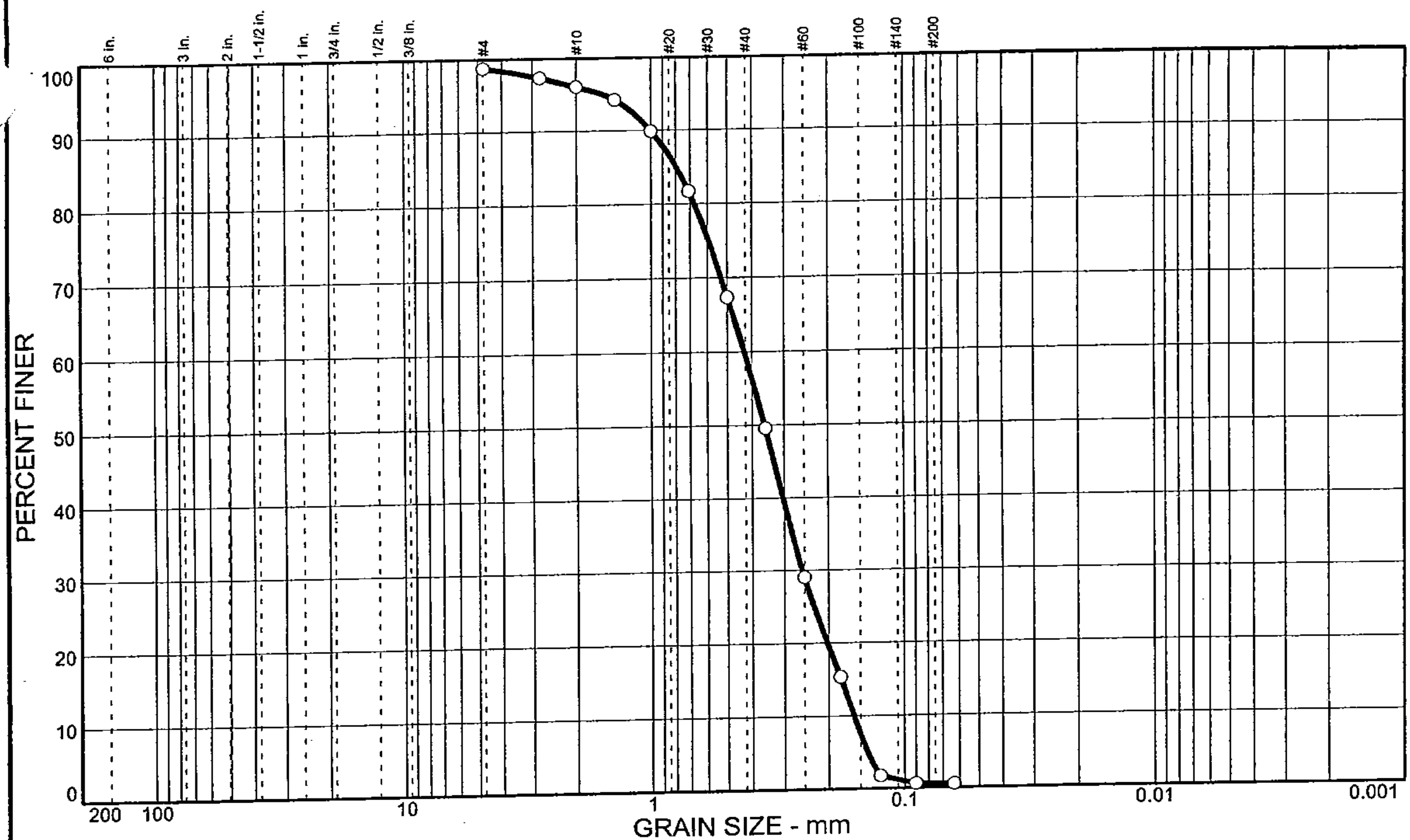
Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			98.2	0.6		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.430		
D_{30}	0.255		
D_{10}	0.159		
	COEFFICIENTS		
C_c	0.95		
C_u	2.70		

SIEVE number size	PERCENT FINER ○		
#4	98.7		
#7	97.3		
#10	96.0		
#14	94.2		
#18	89.9		
#25	81.7		
#35	67.4		
#45	49.5		
#60	29.0		
#80	15.3		
#120	1.7		
#170	0.6		
#230	0.5		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, light brown

REMARKS:

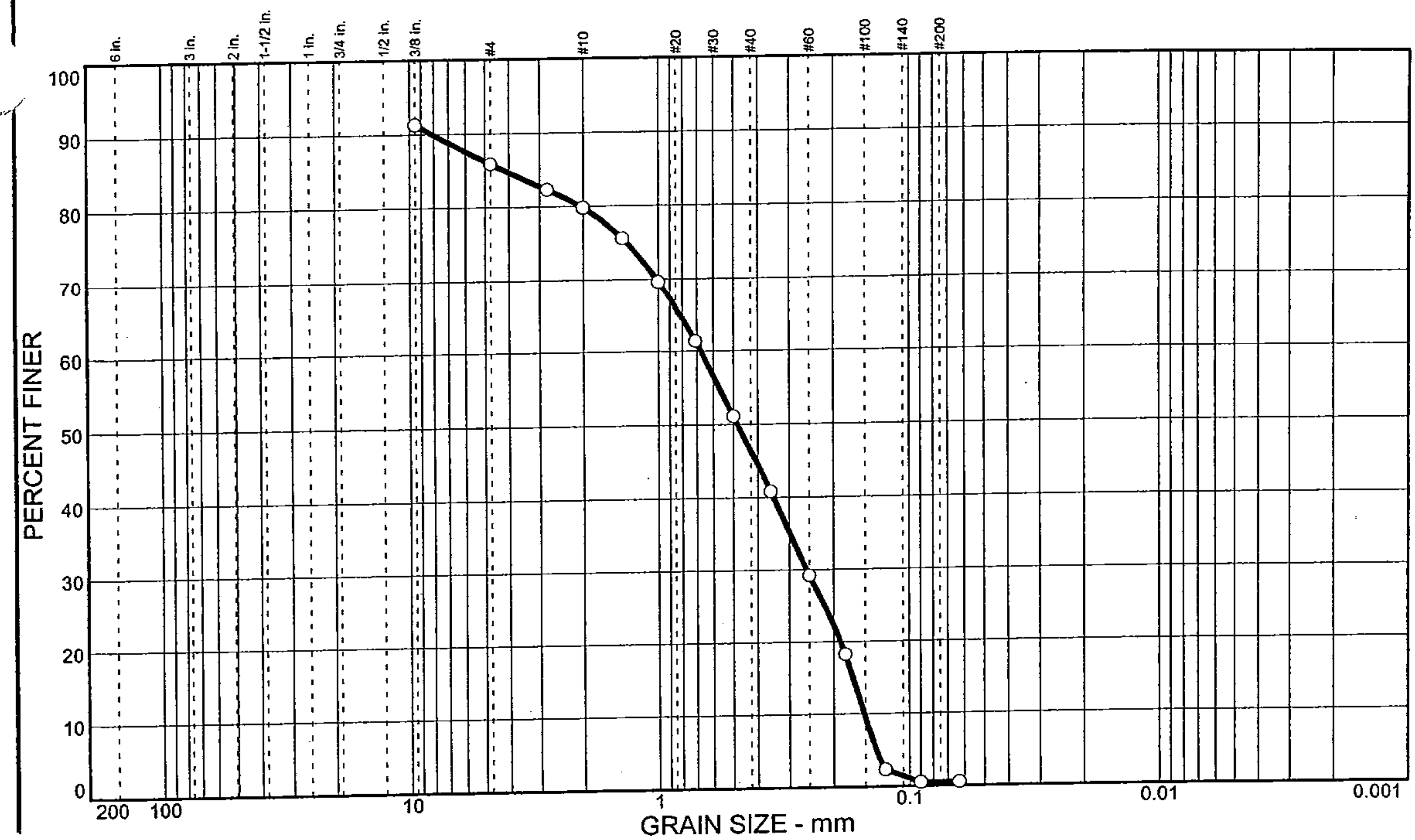
○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 41%

○ Source: P/L-VK01-2 Sample No.: B Elev./Depth: 0.0'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			85.4	0.5		SP	A-1-b		

SIEVE inches size	PERCENT FINER ○		
3/8	91.3		

	GRAIN SIZE		
D_{60}	0.675		
D_{30}	0.256		
D_{10}	0.152		

	COEFFICIENTS		
C_c	0.64		
C_u	4.45		

○ Source: P/L-VK01-2

SIEVE number size	PERCENT FINER ○		
#4	85.9		
#7	82.3		
#10	79.8		
#14	75.6		
#18	69.6		
#25	61.4		
#35	51.1		
#45	40.8		
#60	29.2		
#80	18.2		
#120	2.3		
#170	0.5		
#230	0.5		

Sample No.: C

SOIL DESCRIPTION

○ SAND, medium to fine quartz, little limestone fragments, some sand sized shell fragments, dark gray

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 34%

Elev./Depth: -1.9'

Law Engineering and Environmental Services, Inc.

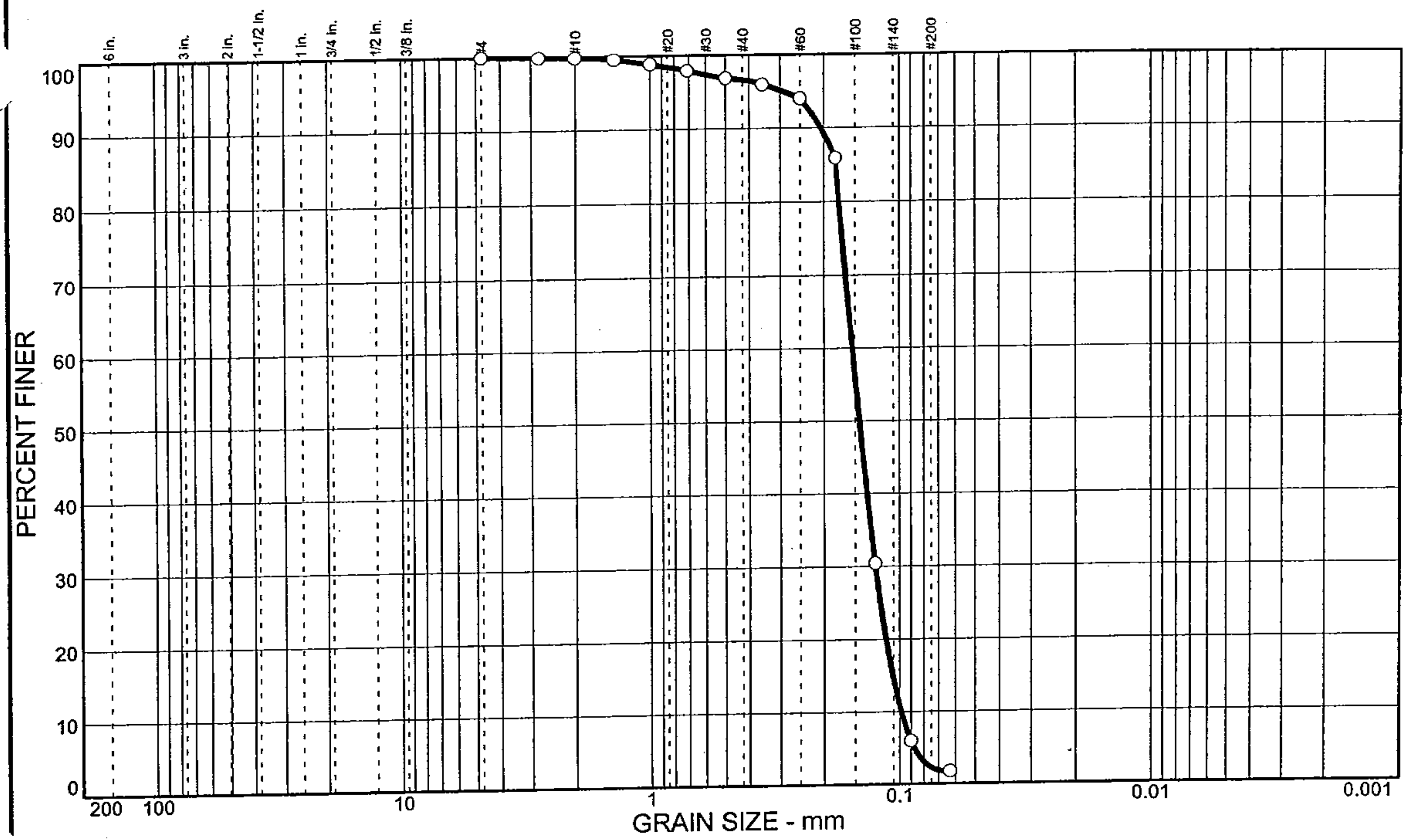
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			97.8	2.2		SP	A-3		

SIEVE inches size	PERCENT FINER O		
	GRAIN SIZE		
D_{60}	0.154		
D_{30}	0.125		
D_{10}	0.0984		
	COEFFICIENTS		
C_c	1.03		
C_u	1.56		

SIEVE number size	PERCENT FINER O		
#4	100.0		
#7	99.9		
#10	99.8		
#14	99.5		
#18	98.8		
#25	97.9		
#35	96.8		
#45	95.9		
#60	94.0		
#80	85.9		
#120	30.4		
#170	6.0		
#230	1.7		

SOIL DESCRIPTION

O SAND, fine quartz, some sand sized shell fragments, light brown-gray

REMARKS:

O 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 28%

O Source: P/L-VK01-2

Sample No.: D

Elev./Depth: -3.9

Law Engineering and Environmental Services, Inc.

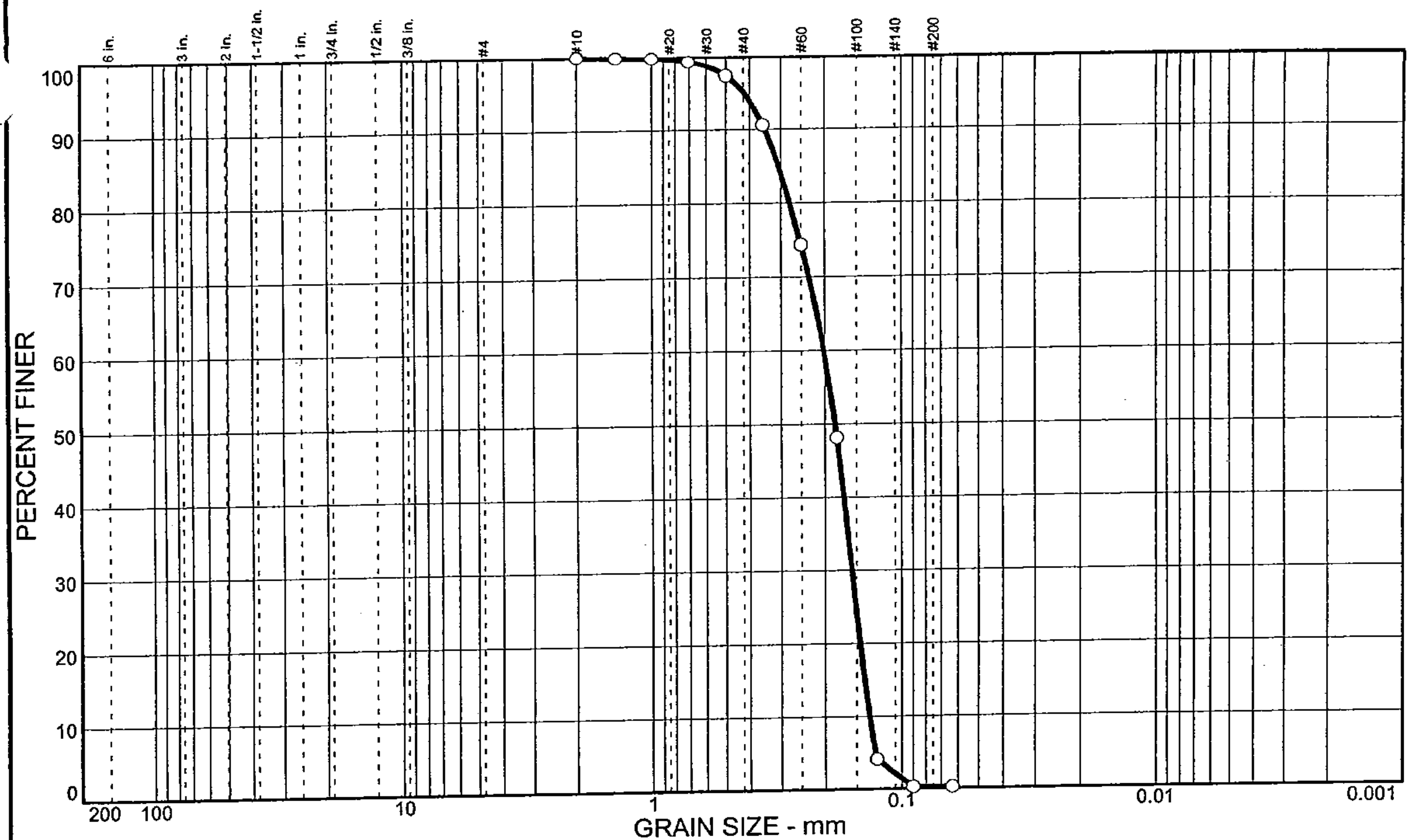
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			99.8	0.2		SP	A-3		

SIEVE inches size	PERCENT FINER O		
	GRAIN SIZE		
D_{60}	0.203		
D_{30}	0.157		
D_{10}	0.134		
	COEFFICIENTS		
C_c	0.91		
C_u	1.52		

SIEVE number size	PERCENT FINER O		
#10	100.0		
#14	99.9		
#18	99.8		
#25	99.3		
#35	97.3		
#45	90.6		
#60	74.3		
#80	48.1		
#120	4.1		
#170	0.2		
#230	0.2		

SOIL DESCRIPTION

O SAND, fine quartz, some fine sand sized shell fragments,light brown-gray

REMARKS:

O 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 33%

O Source: P/L-VK01-3

Sample No.: A

Elev./Depth: +3.6'

Law Engineering and Environmental Services, Inc.

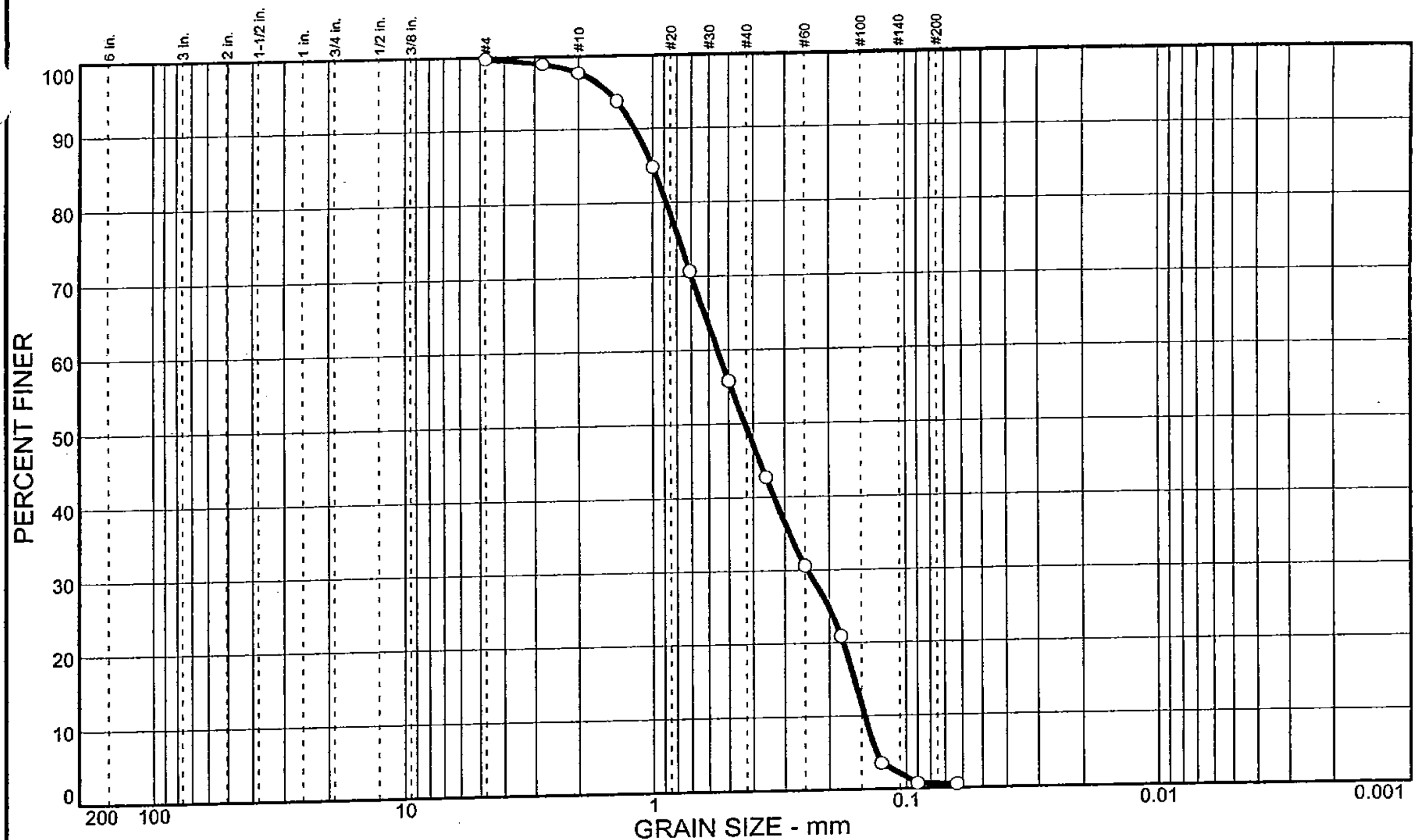
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			99.1	0.6		SP	A-1-b		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.554		
D_{30}	0.245		
D_{10}	0.145		
	COEFFICIENTS		
C_c	0.74		
C_u	3.81		

○ Source: P/L-VK01-3

SIEVE number size	PERCENT FINER ○		
#4	99.7		
#7	98.9		
#10	97.6		
#14	93.7		
#18	84.8		
#25	70.7		
#35	55.8		
#45	42.7		
#60	30.6		
#80	20.9		
#120	3.5		
#170	0.7		
#230	0.5		

Sample No.: B

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments little sand sized limestone fragments, light brown and tan

REMARKS:

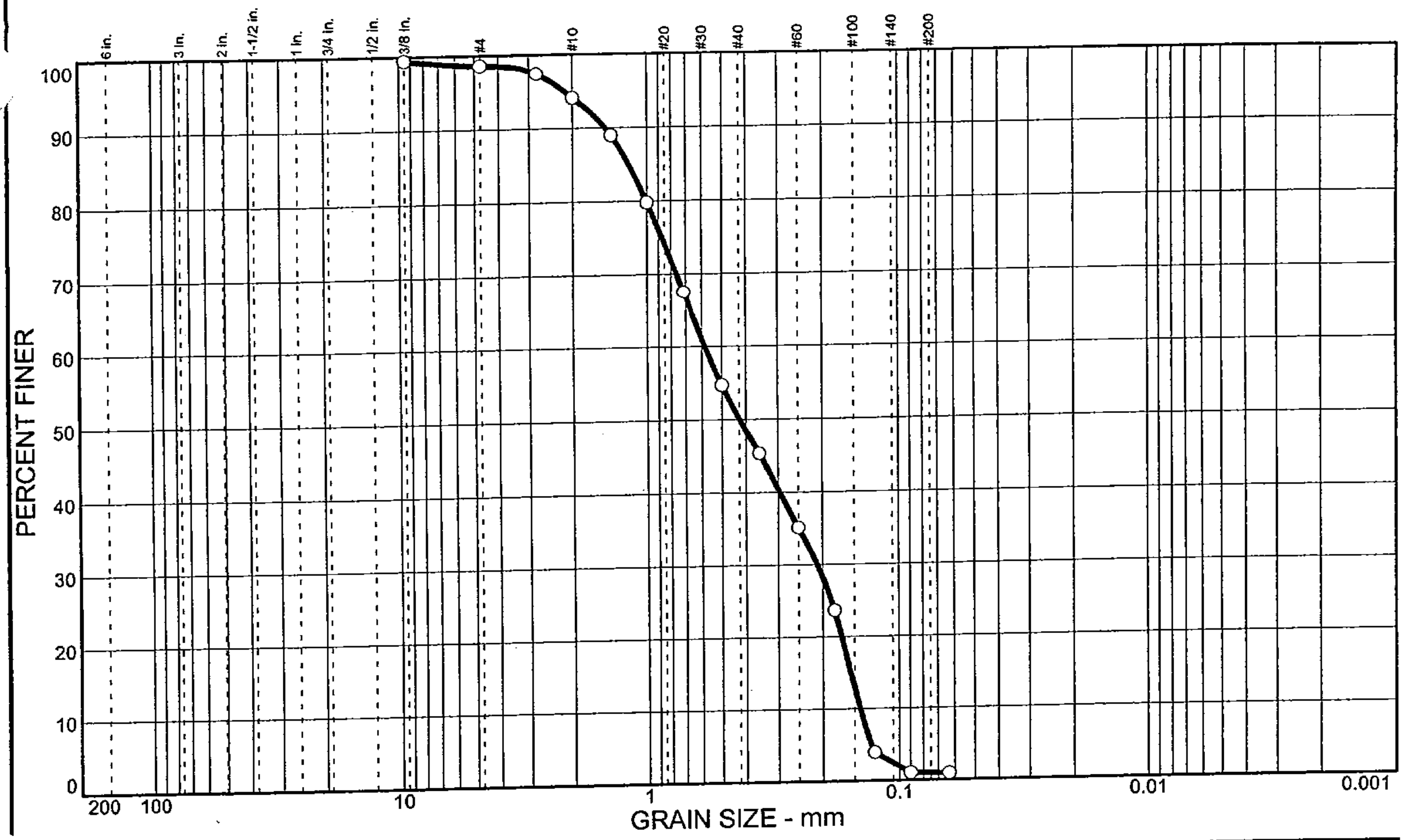
○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 26%

Elev./Depth: +1.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			97.7	1.0		SP	A-1-b		

SIEVE inches size	PERCENT FINER ○		
3/8	99.4		
	GRAIN SIZE		
D_{60}	0.583		
D_{30}	0.211		
D_{10}	0.142		
	COEFFICIENTS		
C_c	0.53		
C_u	4.09		

SIEVE number size	PERCENT FINER ○		
#4	98.6		
#7	97.4		
#10	94.1		
#14	89.0		
#18	79.8		
#25	67.5		
#35	54.7		
#45	45.3		
#60	35.1		
#80	23.6		
#120	3.9		
#170	1.0		
#230	0.9		

SOIL DESCRIPTION

○ SAND, course to fine quartz, some sand sized shell fragments, little sand sized limestone fragments, light brown and orange

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 33%

○ Source: P/L-VK01-3

Sample No.: C

Elev./Depth: +0.5'

Law Engineering and Environmental Services, Inc.

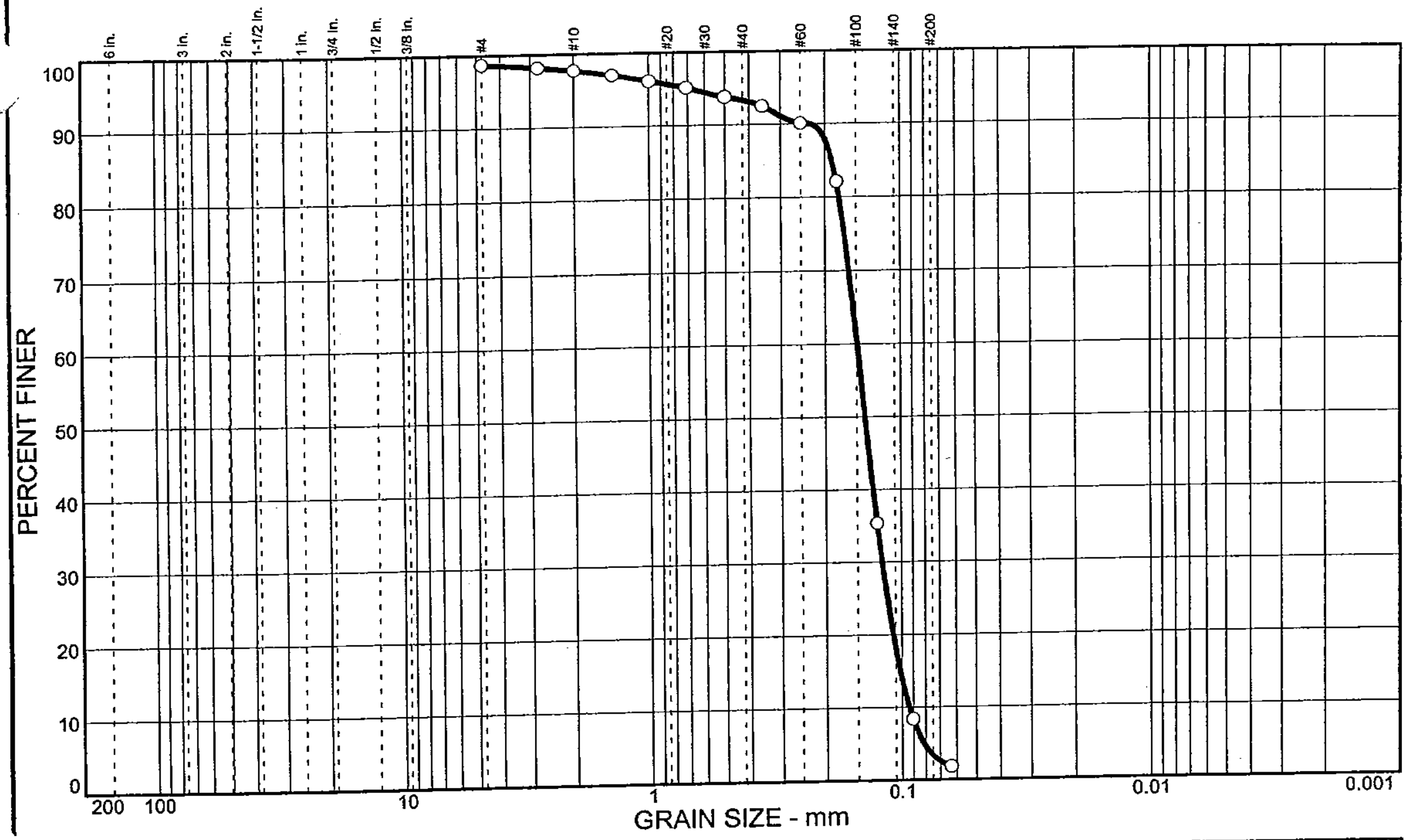
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			95.3	3.4		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.149		
D_{30}	0.120		
D_{10}	0.0931		
	COEFFICIENTS		
C_c	1.03		
C_u	1.60		

○ Source: P/L-VK01-3

SIEVE number size	PERCENT FINER ○		
#4	98.7		
#7	98.2		
#10	97.7		
#14	97.0		
#18	96.1		
#25	95.1		
#35	93.8		
#45	92.5		
#60	90.1		
#80	82.1		
#120	35.3		
#170	8.4		
#230	1.8		

Sample No.: D

SOIL DESCRIPTION

○ SAND, fine quartz, trace sand sized shell fragments, gray and light brown

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 9
Visual Percent Shell: 10%

Elev./Depth: -1.5'

Law Engineering and Environmental Services, Inc.

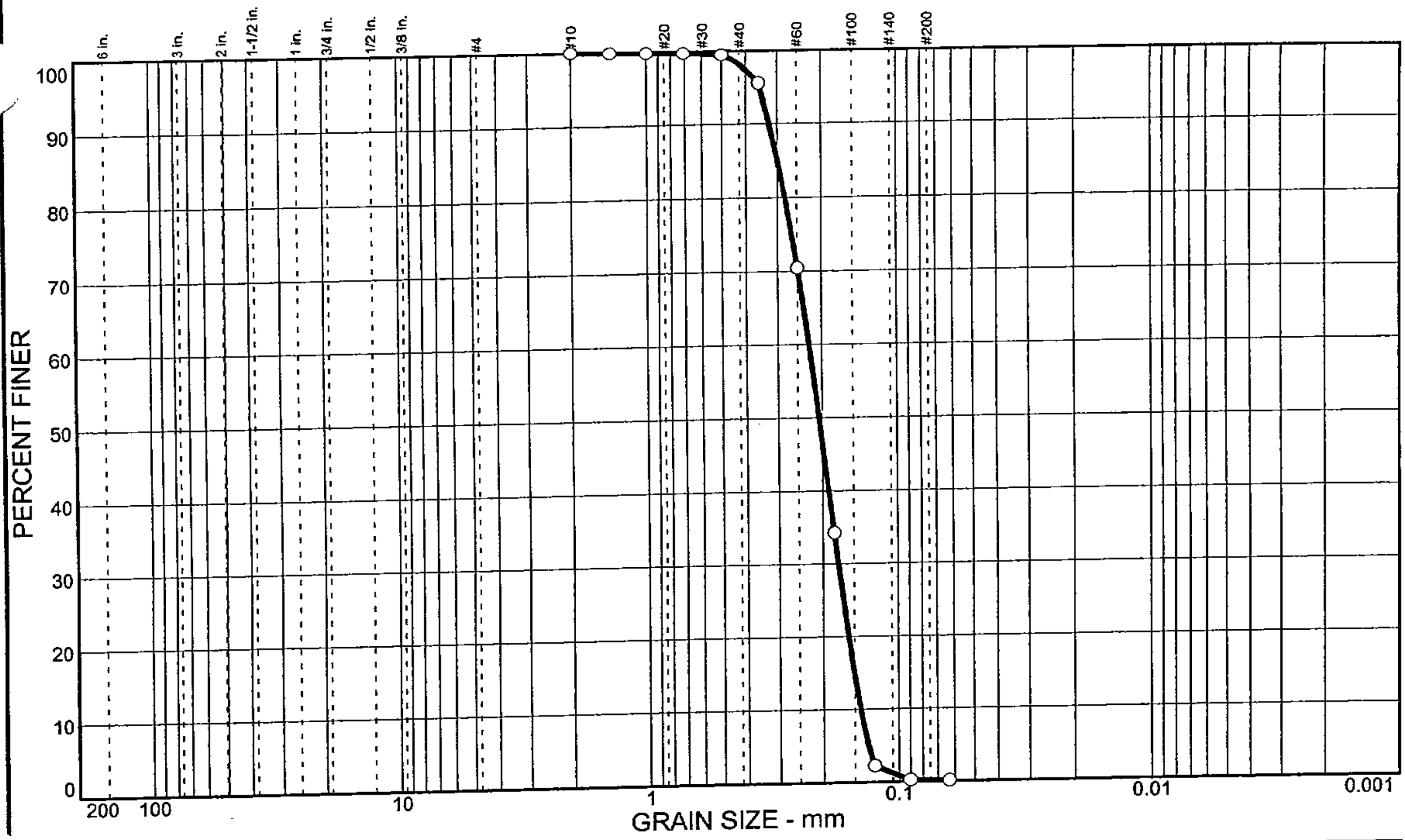
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			99.9	0.1		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.225		
D_{30}	0.173		
D_{10}	0.142		
	COEFFICIENTS		
C_c	0.94		
C_u	1.59		

SIEVE number size	PERCENT FINER ○		
#10	100.0		
#14	99.9		
#18	99.8		
#25	99.7		
#35	99.4		
#45	95.5		
#60	70.5		
#80	34.2		
#120	2.2		
#170	0.2		
#230	0.1		

SOIL DESCRIPTION

○ SAND, fine quartz, some fine sand sized shell fragments,trace organics, light brown

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 24%

○ Source: P/L-VK01-4

Sample No.: A

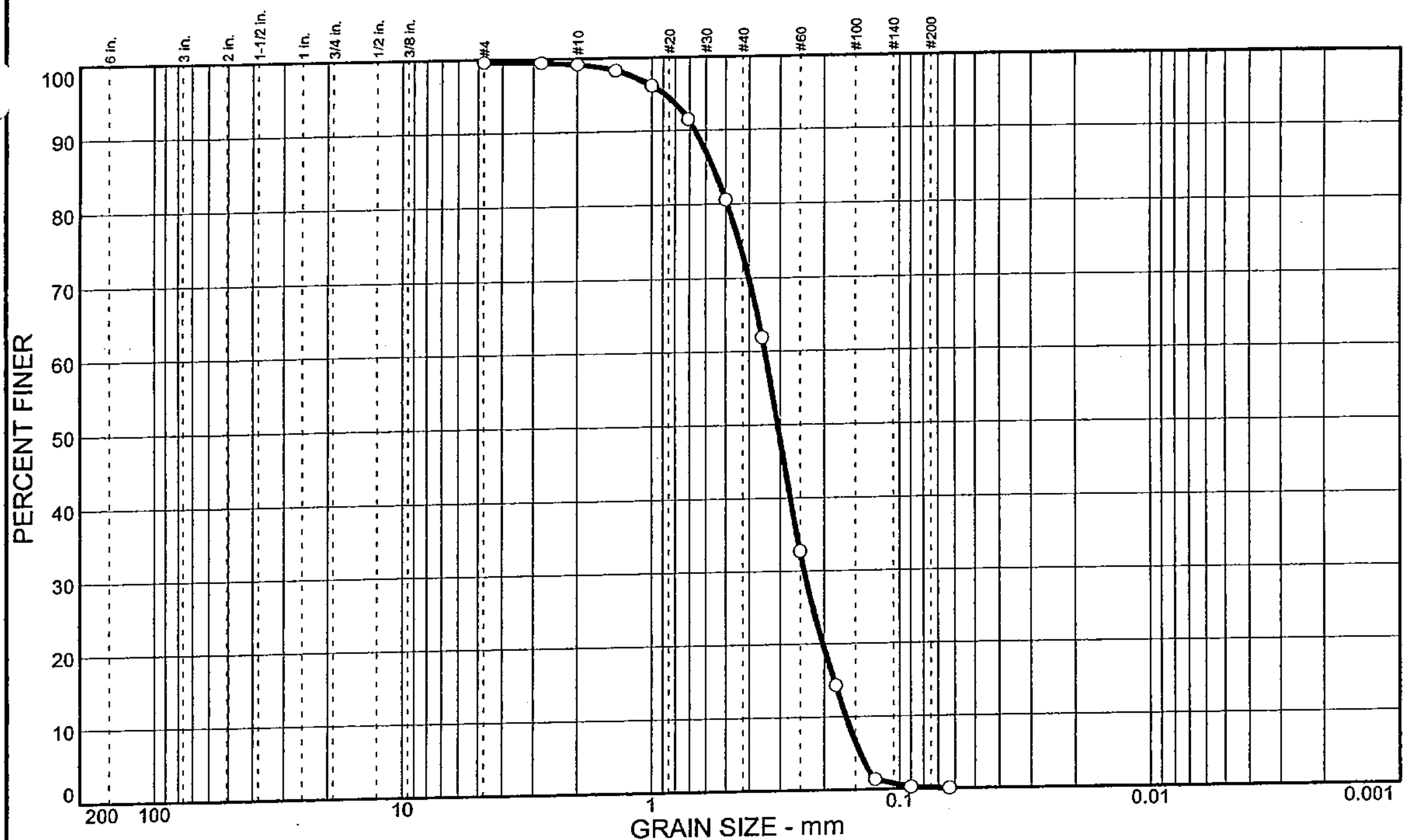
Elev./Depth: +2.6

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			99.5	0.1	0.0	SP	A-3		

SIEVE inches size	PERCENT FINER O		

	GRAIN SIZE		
D_{60}	0.347		
D_{30}	0.241		
D_{10}	0.164		

	COEFFICIENTS		
C_c	1.02		
C_u	2.12		

SIEVE number size	PERCENT FINER O		
#4	99.6		
#7	99.4		
#10	99.1		
#14	98.2		
#18	96.1		
#25	91.5		
#35	80.6		
#45	61.8		
#60	32.7		
#80	14.3		
#120	1.3		
#170	0.2		
#230	0.0		

SOIL DESCRIPTION

O SAND, medium to fine quartz, little sand sized shell fragments, little sand sized limestone fragments, brown

REMARKS:

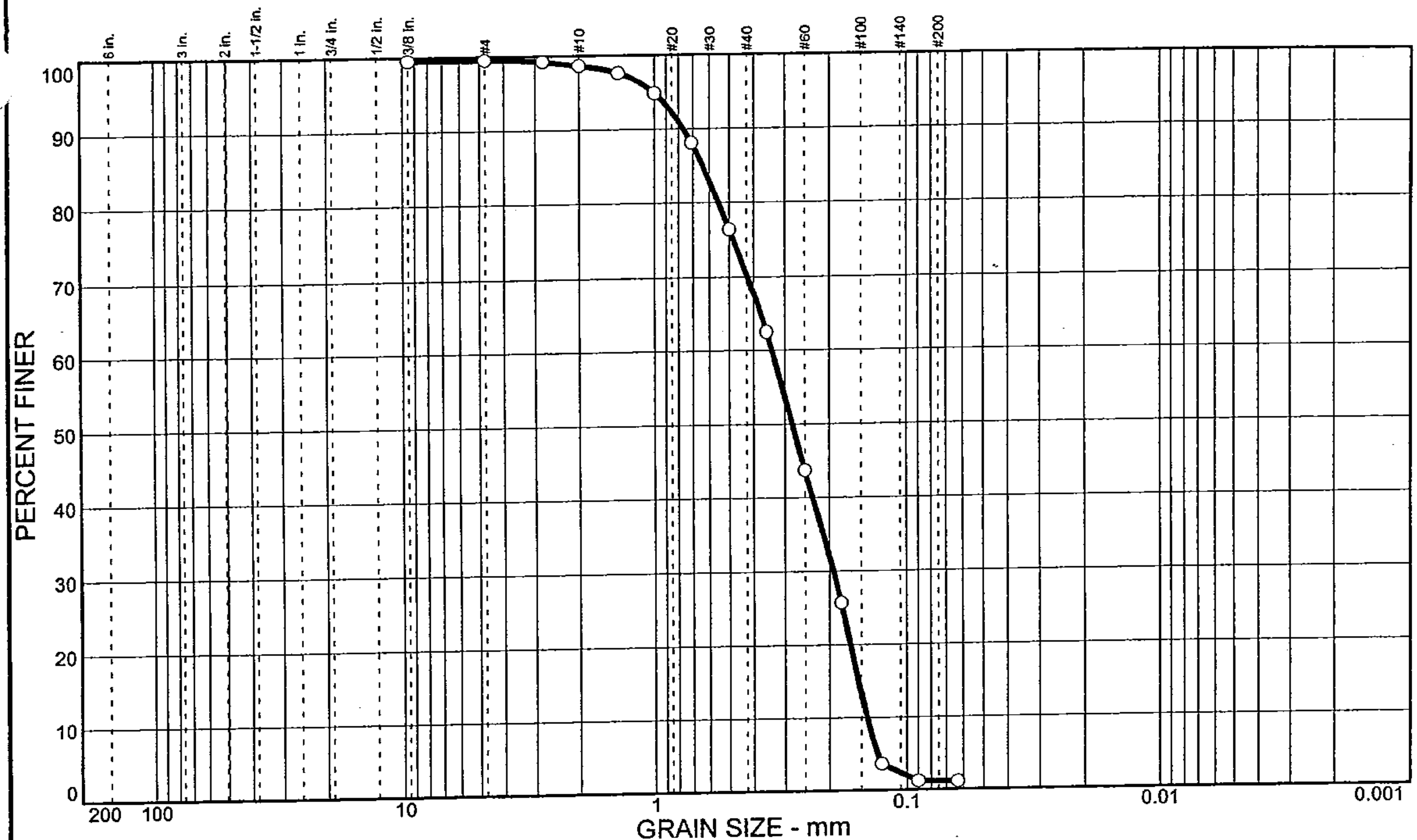
O 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 15%

O Source: P/L-VK01-4 Sample No.: B Elev./Depth: +1.2

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			98.4	1.2		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	99.5		
	GRAIN SIZE		
D_{60}	0.338		
D_{30}	0.193		
D_{10}	0.142		
	COEFFICIENTS		
C_c	0.78		
C_u	2.37		

SIEVE number size	PERCENT FINER ○		
#4	99.5		
#7	99.2		
#10	98.6		
#14	97.6		
#18	94.8		
#25	88.1		
#35	76.4		
#45	62.5		
#60	43.7		
#80	25.7		
#120	3.6		
#170	1.2		
#230	1.1		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, trace sand sized limestone fragments, gray and brown

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 33%

○ Source: P/L-VK01-4

Sample No.: C

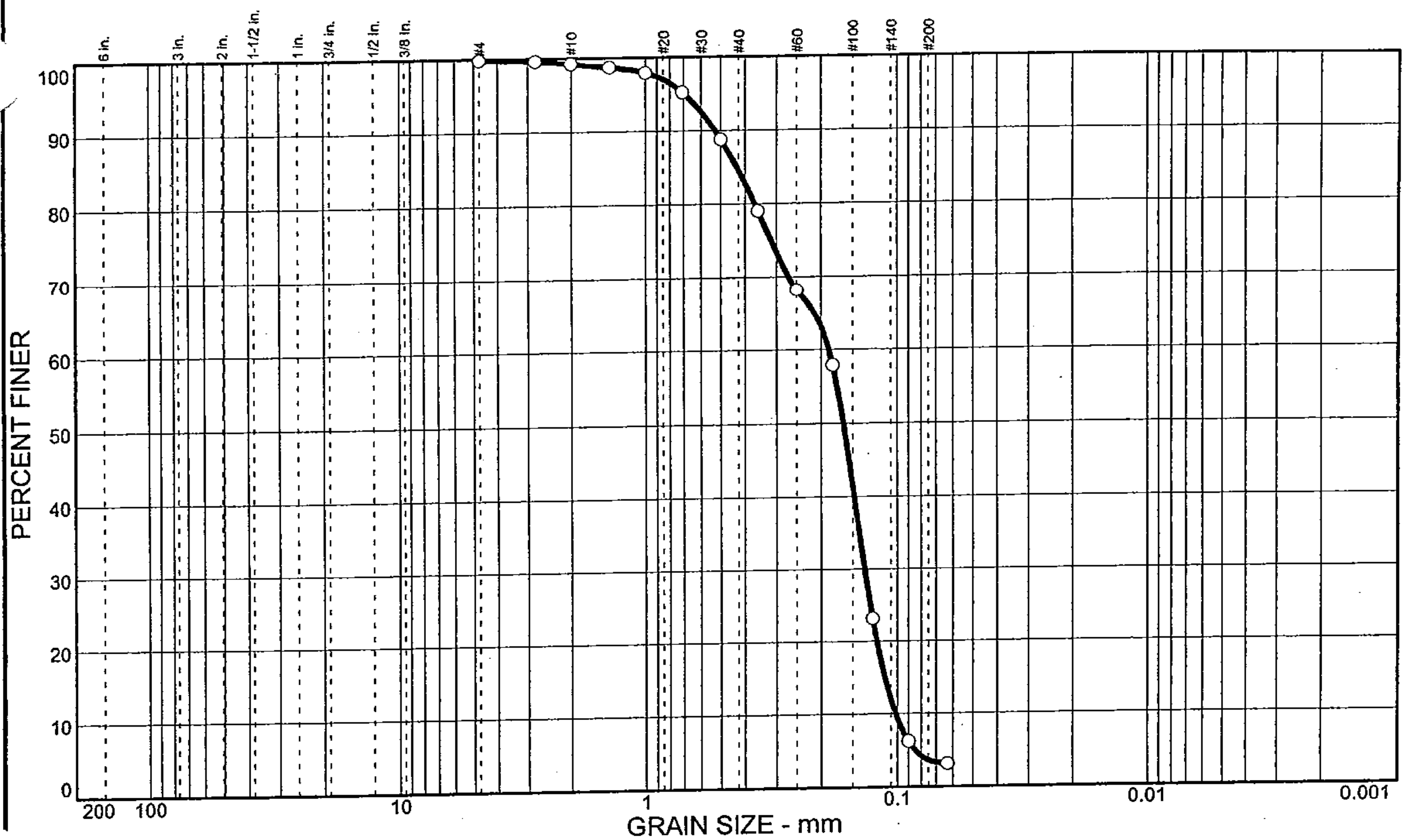
Elev./Depth: +0.1'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			96.2	3.8		SP	A-3		

SIEVE inches size	PERCENT FINER O		
	GRAIN SIZE		
D_{60}	0.186		
D_{30}	0.134		
D_{10}	0.101		
	COEFFICIENTS		
C_c	0.96		
C_u	1.84		

O Source: P/L-VK01-4

SIEVE number size	PERCENT FINER O		
#4	99.8		
#7	99.6		
#10	99.2		
#14	98.7		
#18	97.9		
#25	95.2		
#35	88.8		
#45	79.0		
#60	68.2		
#80	57.9		
#120	23.1		
#170	6.2		
#230	3.1		

Sample No.: D

SOIL DESCRIPTION

O SAND, fine quartz, some sand sized shell fragments, gray and light brown

REMARKS:

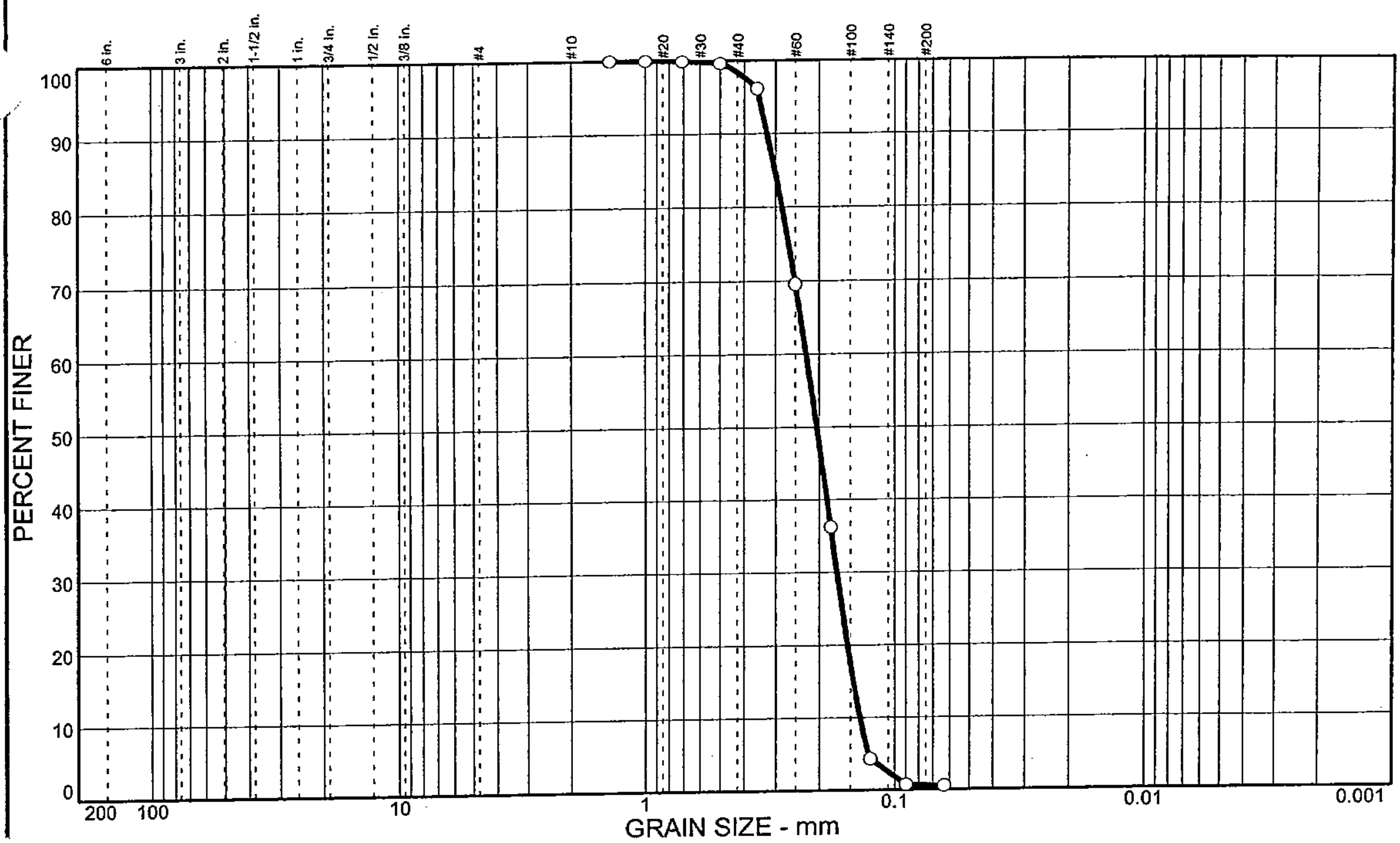
O 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 25%

Elev./Depth: -1.4'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			99.4	0.6		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.226		
D_{30}	0.170		
D_{10}	0.137		
	COEFFICIENTS		
C_c	0.93		
C_u	1.65		

SIEVE number size	PERCENT FINER ○		
#14	100.0		
#18	100.0		
#25	99.9		
#35	99.6		
#45	96.1		
#60	69.6		
#80	36.2		
#120	4.3		
#170	0.7		
#230	0.5		

SOIL DESCRIPTION

○ SAND, fine quartz, some sand sized shell fragments, light brown

REMARKS:

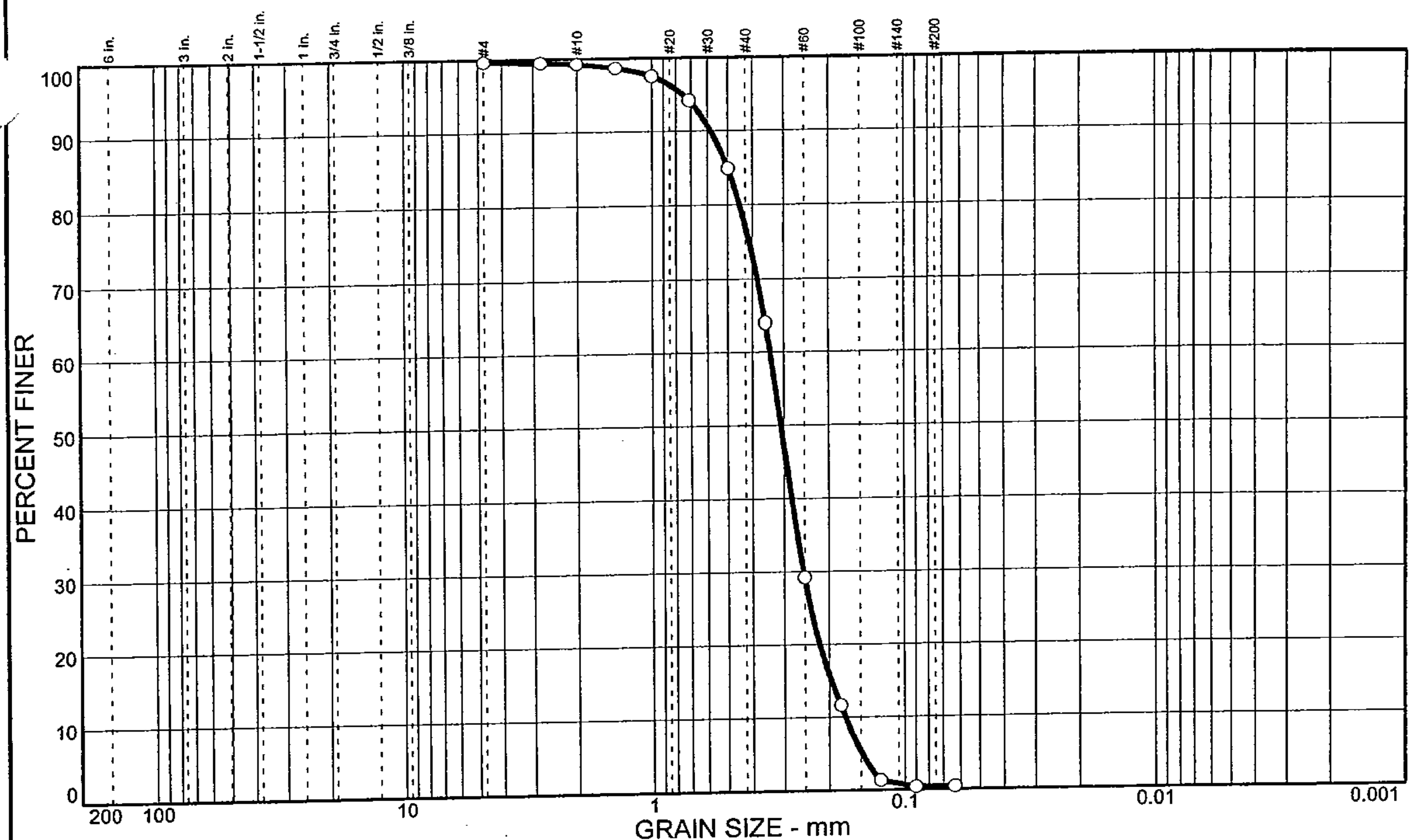
○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 26%

○ Source: P/L-VK01-5 Sample No.: A Elev./Depth: +2.5'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			99.2	0.4		SP	A-3		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.341		
D_{30}	0.252		
D_{10}	0.172		
	COEFFICIENTS		
C_c	1.09		
C_u	1.98		

○ Source: P/L-VK01-5

SIEVE number size	PERCENT FINER ○		
#4	99.6		
#7	99.4		
#10	99.2		
#14	98.6		
#18	97.4		
#25	94.1		
#35	84.9		
#45	63.9		
#60	29.2		
#80	11.6		
#120	1.3		
#170	0.4		
#230	0.4		

Sample No.: B

SOIL DESCRIPTION

○ SAND, medium to fine quartz, little sand sized shell fragments, trace sand sized limestone fragments, brown

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 19%

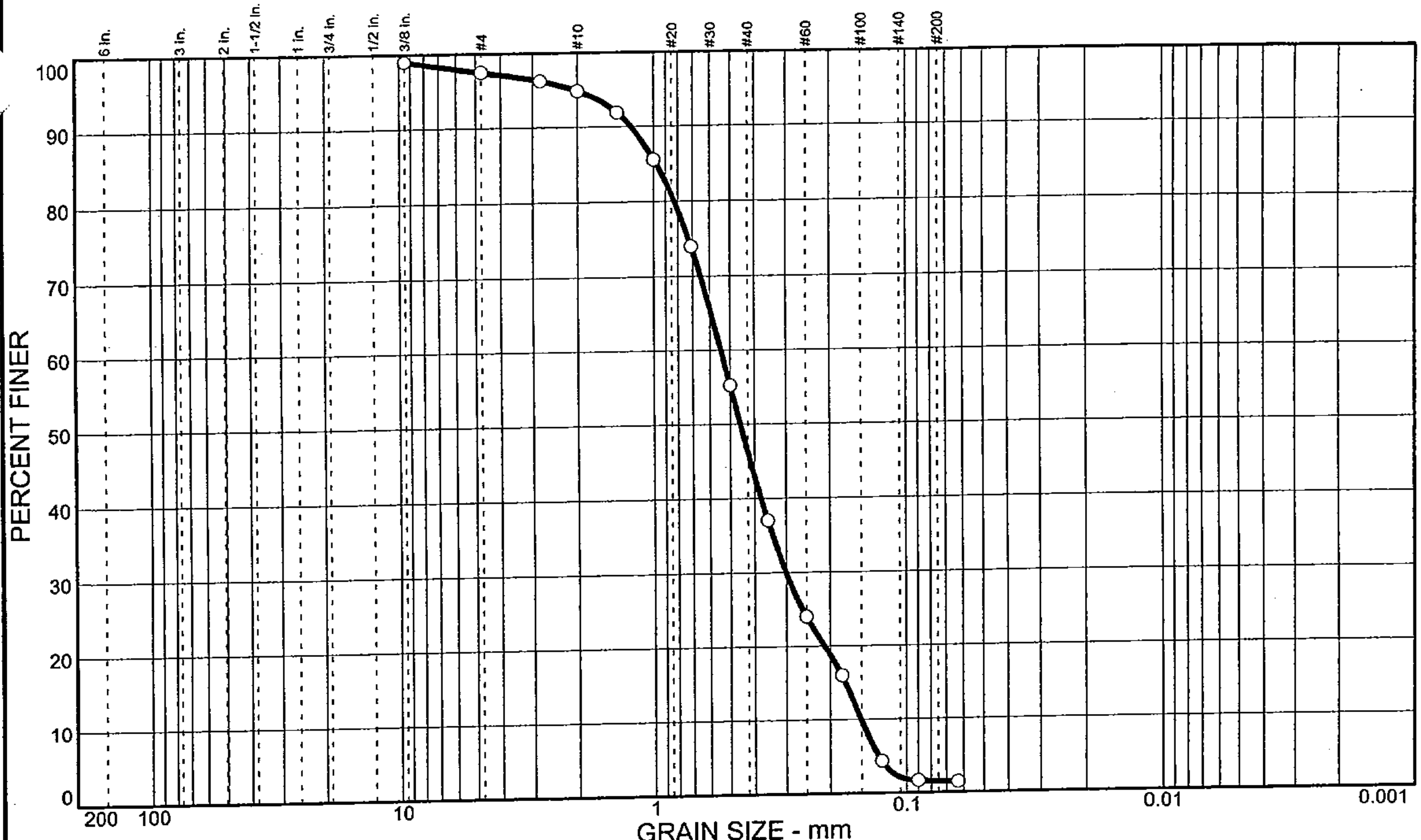
Elev./Depth: +1.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			95.9	1.5		SP	A-1-b		

SIEVE inches size	PERCENT FINER ○		
3/8	98.9		
	GRAIN SIZE		
D_{60}	0.544		
D_{30}	0.301		
D_{10}	0.151		
	COEFFICIENTS		
C_c	1.10		
C_u	3.60		

○ Source: P/L-VK01-5

SIEVE number size	PERCENT FINER ○		
#4	97.4		
#7	96.2		
#10	94.8		
#14	91.9		
#18	85.6		
#25	74.0		
#35	55.2		
#45	37.0		
#60	24.0		
#80	16.0		
#120	4.3		
#170	1.6		
#230	1.4		

Sample No.: C

SOIL DESCRIPTION

○ SAND, medium to fine quartz, some sand sized shell fragments, trace sand sized limestone fragments, brown

REMARKS:

○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 45%

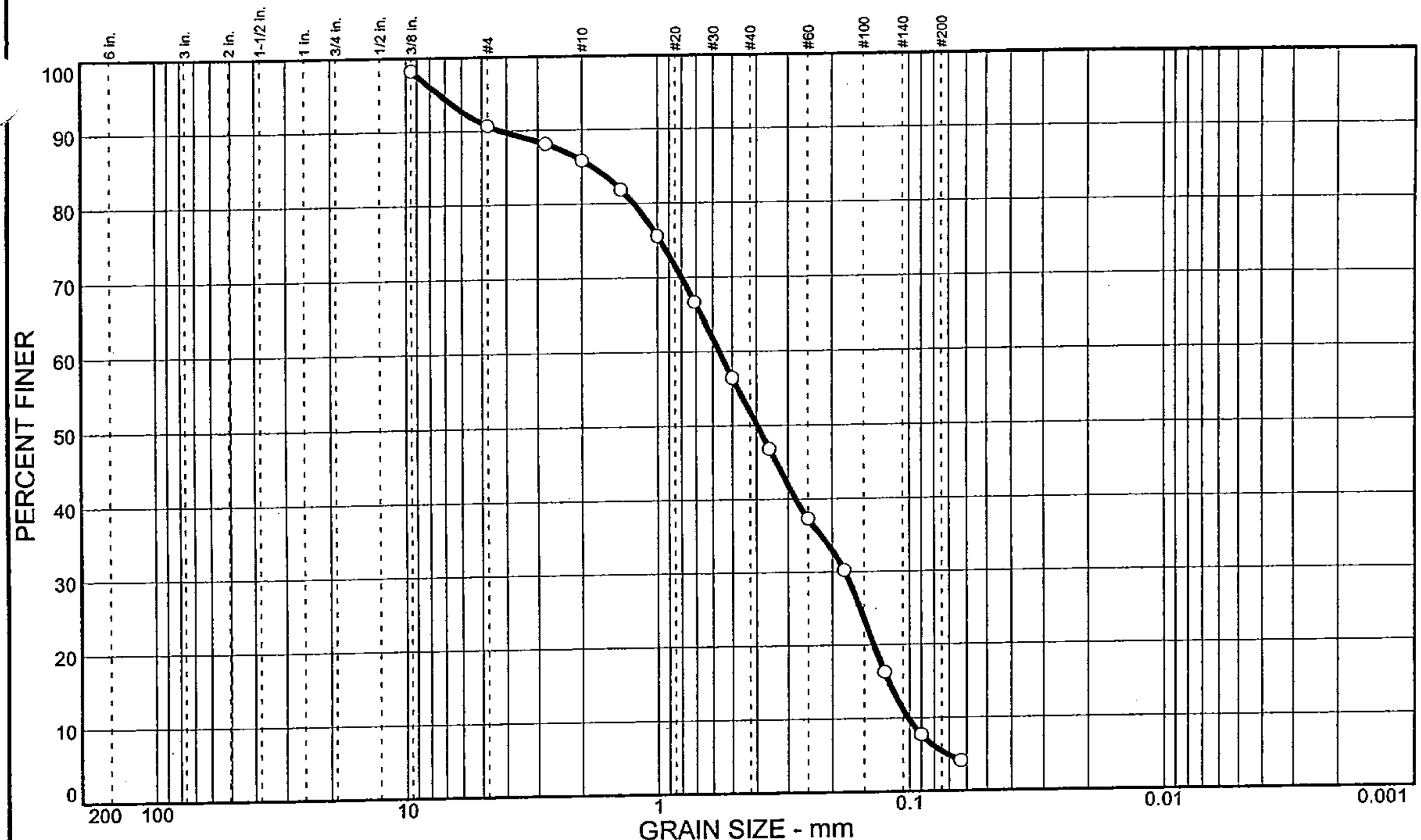
Elev./Depth: +0.7'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			85.3	5.4		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	98.2		
	GRAIN SIZE		
D_{60}	0.565		
D_{30}	0.179		
D_{10}	0.101		
	COEFFICIENTS		
C_c	0.56		
C_u	5.60		

SIEVE number size	PERCENT FINER ○		
#4	90.7		
#7	88.2		
#10	85.9		
#14	81.9		
#18	75.6		
#25	66.7		
#35	56.4		
#45	46.8		
#60	37.3		
#80	30.2		
#120	16.3		
#170	7.7		
#230	4.1		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, little sand sized shell fragments, little sand sized limestone fragments, trace silt, dark gray

REMARKS:

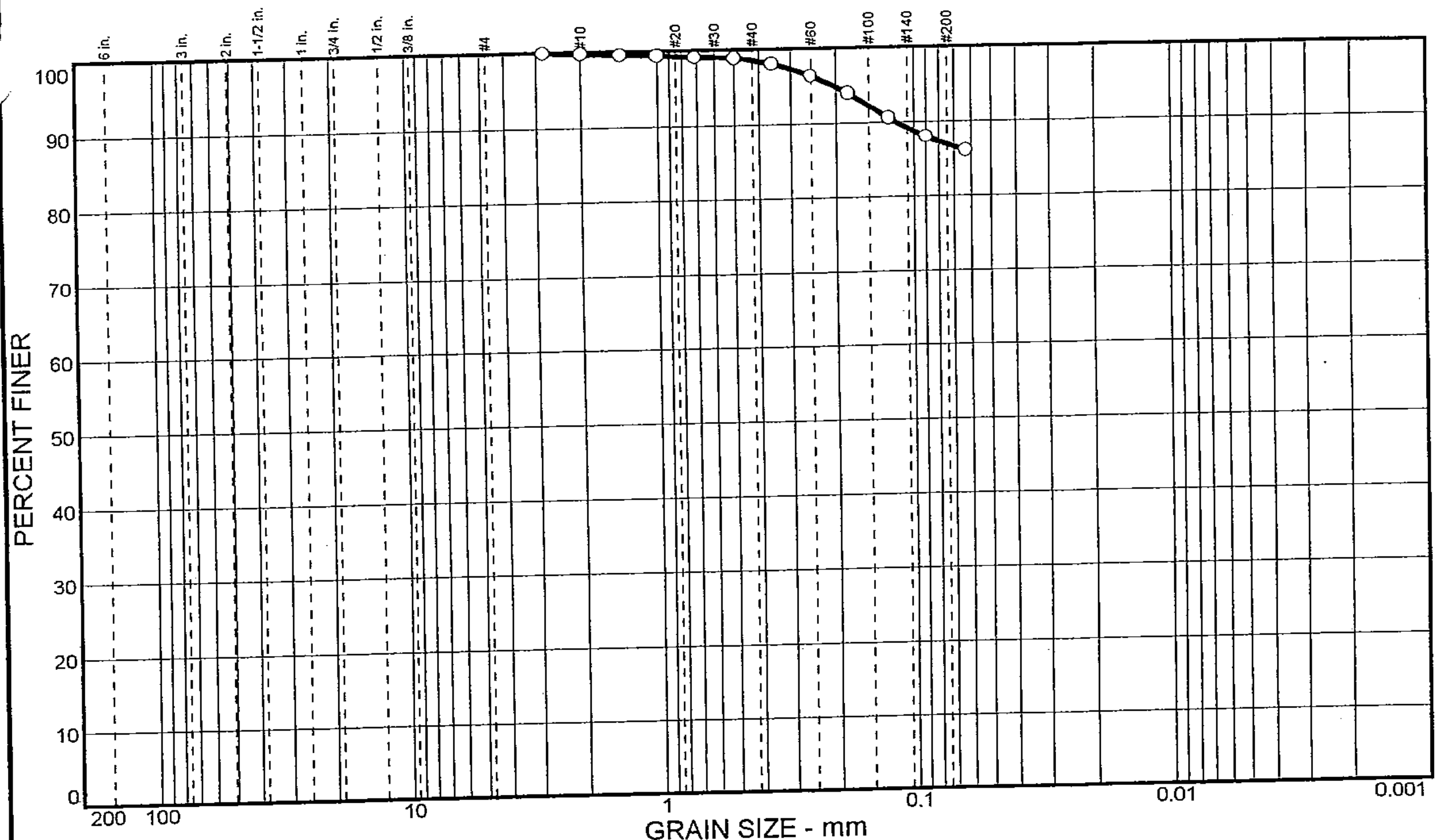
○ 5 Beach Profile Line Surface Samples-Area 5
Visual Percent Shell: 20%

○ Source: P/L-VK01-5 Sample No.: D Elev./Depth: -0.8'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			13.0	87.0		ML	A-4(0)		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}			
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#7	100.0		
#10	99.8		
#14	99.6		
#18	99.4		
#25	99.1		
#35	98.9		
#45	98.0		
#60	96.3		
#80	93.9		
#120	90.5		
#170	88.0		
#230	86.1		

SOIL DESCRIPTION

○ SILT, little fine quartz sand, little organics, dark brown

REMARKS:

○ Surface Samples at High Zone in Marsh-Area 6
Visual Percent Shell: 3%
Percent Organic: 13.5%

○ Source: SS-VK01-1

Sample No.: 1

Law Engineering and Environmental Services, Inc.

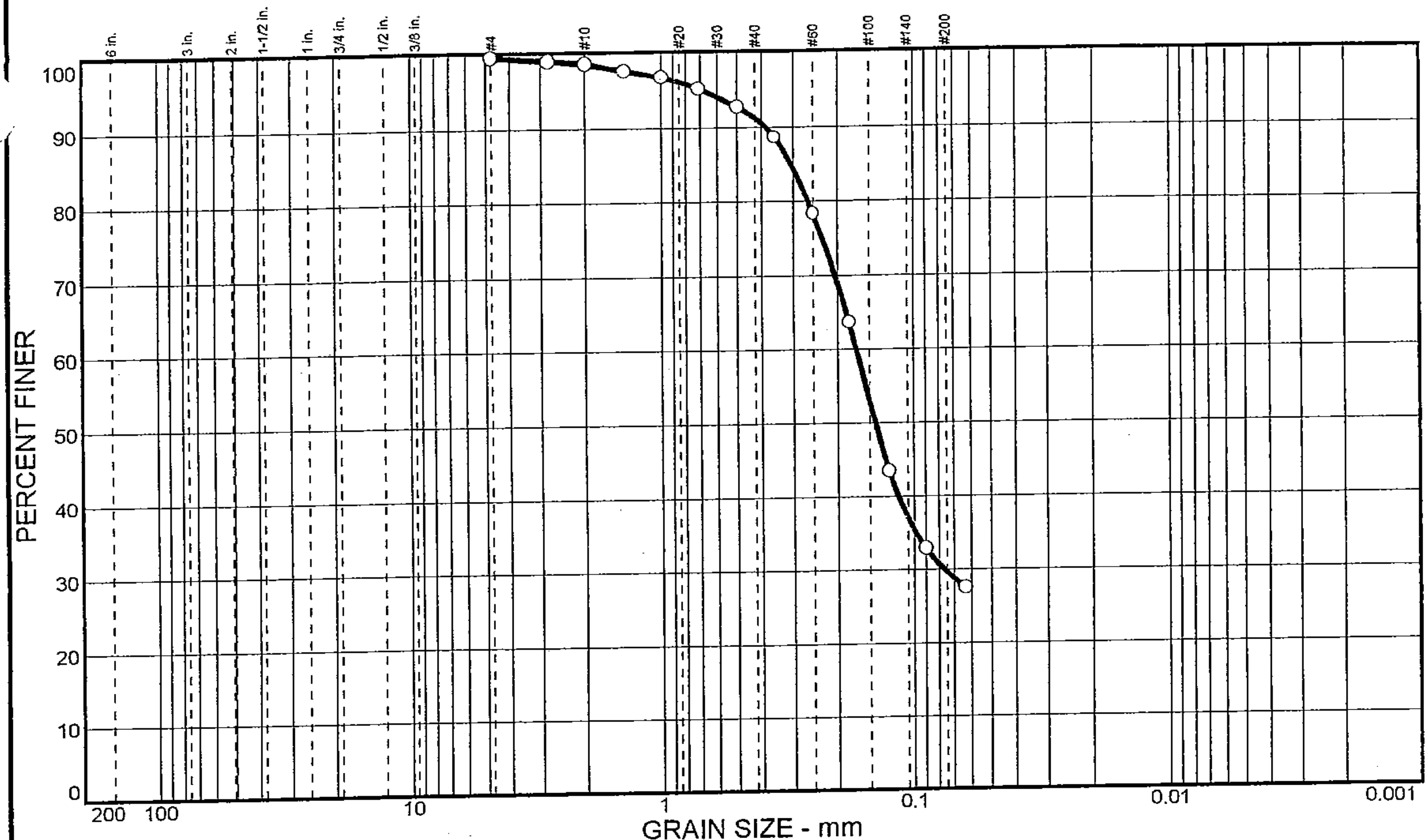
Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
		69.8	29.8		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
	GRAIN SIZE		
D_{60}	0.168		
D_{30}	0.0763		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

O Source: SS-VK01-2

SIEVE number size	PERCENT FINER O		
#4	99.5		
#7	99.0		
#10	98.6		
#14	97.7		
#18	96.8		
#25	95.2		
#35	92.7		
#45	88.6		
#60	78.3		
#80	63.7		
#120	43.5		
#170	32.9		
#230	27.5		

Sample No.: 1

SOIL DESCRIPTION

O SAND, fine quartz, some silt, some sand sized shell fragments, little organics, dark brown and brown

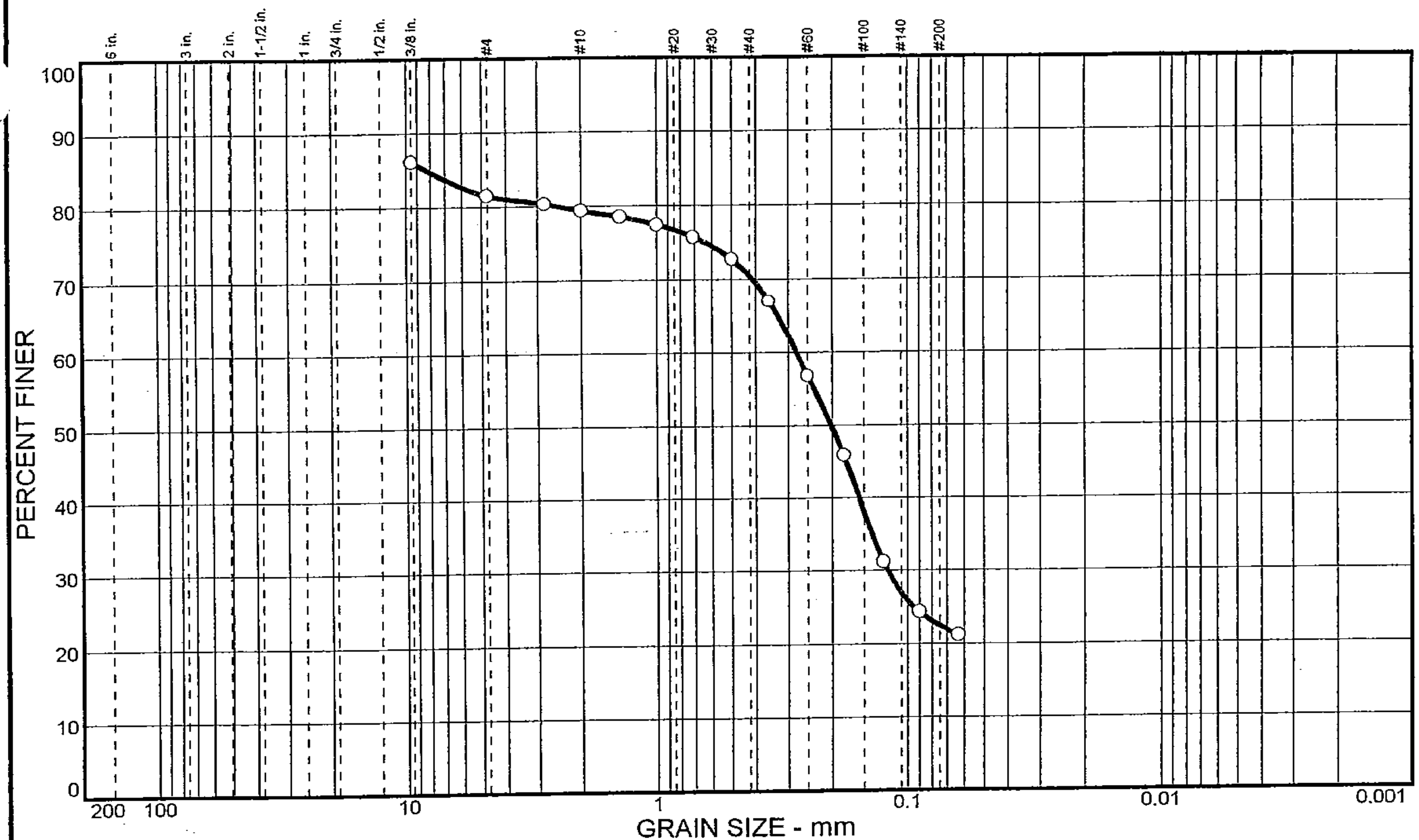
REMARKS:

O Surface Samples at High Zone in Marsh-Area-6
Visual Percent Shell: 34%
Percent Organic: 10.8%

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			59.1	22.4		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER O		
3/8	86.1		
	GRAIN SIZE		
D_{60}	0.277		
D_{30}	0.120		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

O Source: SS-VK01-3

SIEVE number size	PERCENT FINER O		
#4	81.5		
#7	80.3		
#10	79.3		
#14	78.5		
#18	77.4		
#25	75.7		
#35	72.7		
#45	67.0		
#60	56.8		
#80	45.9		
#120	31.2		
#170	24.3		
#230	21.1		

Sample No.: 1

SOIL DESCRIPTION

O SAND, fine quartz, some sand sized shell fragments, some silt, some organics, trace limestone fragments, dark brown and brown

REMARKS:

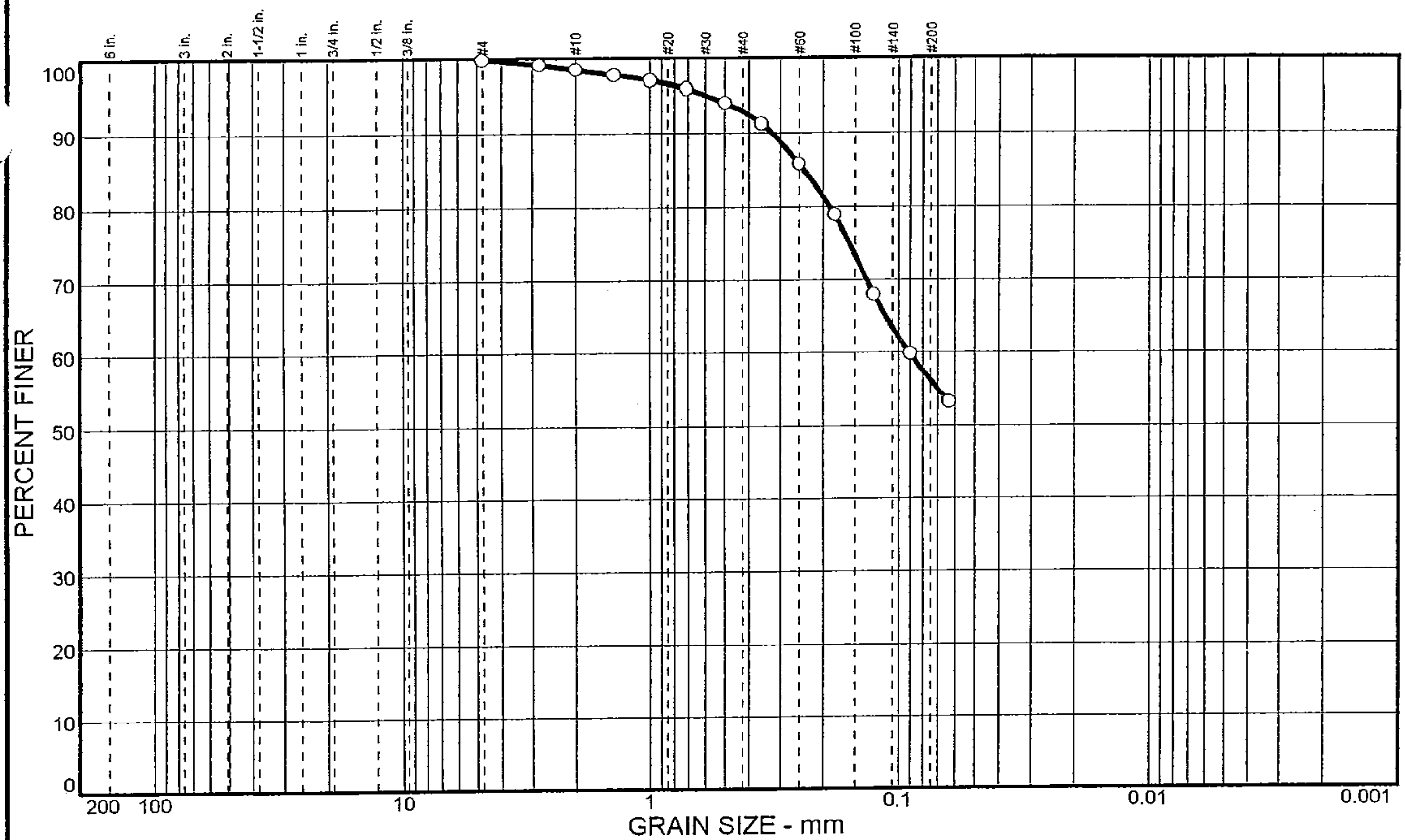
O Surface Samples at High Zone in Marsh-Area 6
Visual Percent Shell: 31%
Percent Organic: 24.3%

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07

Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			43.6	56.4		CH	A-6(0)		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.0909		
D_{30}			
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

○ Source: SS-VK01-4

SIEVE number size	PERCENT FINER ○		
#4	99.8		
#7	99.1		
#10	98.5		
#14	97.8		
#18	97.1		
#25	96.0		
#35	94.1		
#45	91.2		
#60	85.7		
#80	78.8		
#120	68.0		
#170	59.8		
#230	53.2		

Sample No.: 1

SOIL DESCRIPTION

○ CLAY, sandy fine quartz sand, little sand sized shell fragments, some organics, trace sand sized limestone fragments, brown-gray

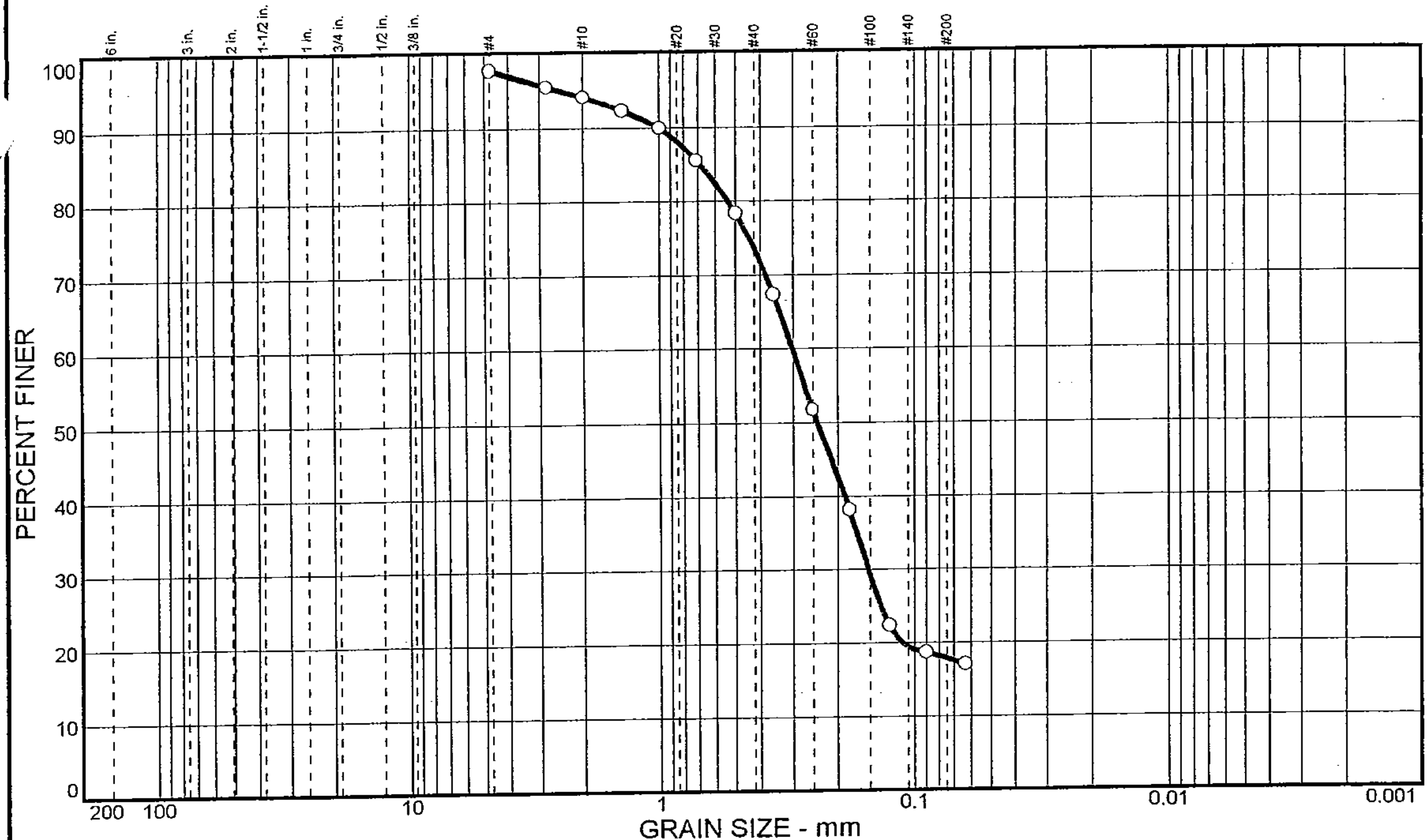
REMARKS:

○ Surface Samples at High Zone in Marsh-Area 6
Visual Percent Shell: 11%
Percent Organic: 5.5%

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07
Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			79.9	17.9		SM	A-2-4(0)		

SIEVE inches size	PERCENT FINER ○		
	GRAIN SIZE		
D_{60}	0.300		
D_{30}	0.152		
D_{10}			
	COEFFICIENTS		
C_c			
C_u			

SIEVE number size	PERCENT FINER ○		
#4	97.7		
#7	95.6		
#10	94.2		
#14	92.3		
#18	89.9		
#25	85.5		
#35	78.3		
#45	67.4		
#60	51.8		
#80	38.2		
#120	22.3		
#170	18.6		
#230	17.0		

SOIL DESCRIPTION

○ SAND, medium to fine quartz, little sand sized limestone fragments, little sand sized shell fragments, little silt, trace organics, dark gray

REMARKS:

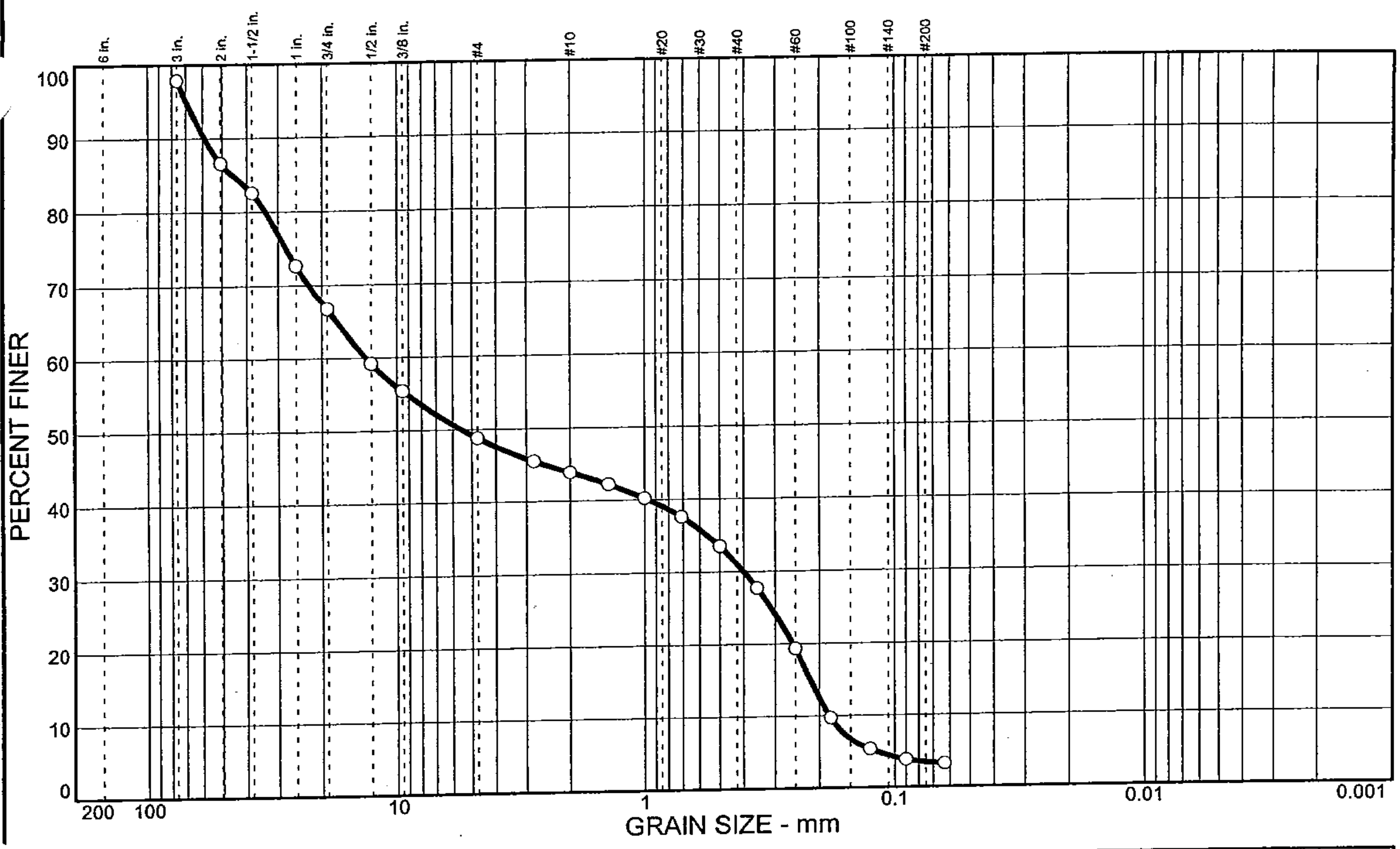
○ Surface Samples at High Zone in Marsh-Area 6
Visual Percent Shell: 18%
Percent Organic: 5.1%

○ Source: SS-VK01-5 Sample No.: 1 Elev./Depth: +2.5'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O	2.1	49.1	45.4	3.4		GP	A-1-b		

SIEVE inches size	PERCENT FINER O		
3	97.9		
2	86.6		
1.5	82.6		
1	72.7		
.75	66.7		
.50	59.2		
.375	55.4		
	GRAIN SIZE		
D_{60}	13.3		
D_{30}	0.401		
D_{10}	0.182		
	COEFFICIENTS		
C_c	0.07		
C_u	73.16		

SIEVE number size	PERCENT FINER O		
#4	48.8		
#7	45.5		
#10	43.9		
#14	42.2		
#18	40.2		
#25	37.6		
#35	33.5		
#45	27.7		
#60	19.3		
#80	9.7		
#120	5.3		
#170	3.8		
#230	3.2		

SOIL DESCRIPTION

O LIMESTONE, sandy, medium to fine quartz, little sand sized shell fragments light brown-tan

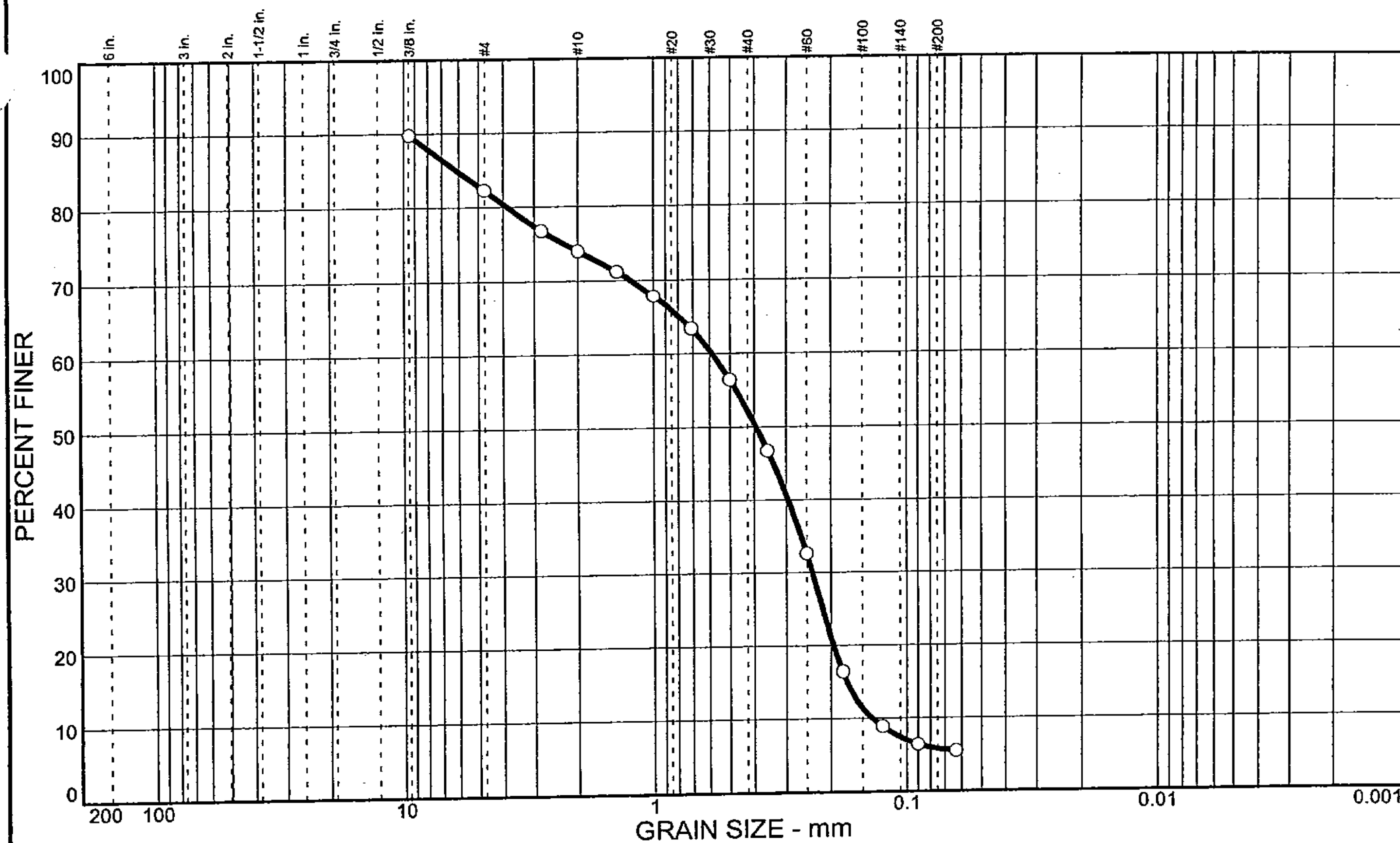
REMARKS:

O Percent Carbonate: 84.1%
Visual Percent Shell: 22%

O Source: TP-VKDA-1 Sample No.: 1A (Bulk) Elev./Depth: +24.8'

Law Engineering and Environmental Services, Inc.	Client: USACE, Jacksonville District Project: Virginia Key Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○			76.5	5.8		SP-SM	A-3		

SIEVE inches size	PERCENT FINER ○		
3/8	89.8		
	GRAIN SIZE		
D_{60}	0.588		
D_{30}	0.238		
D_{10}	0.137		
	COEFFICIENTS		
C_c	0.70		
C_u	4.28		

SIEVE number size	PERCENT FINER ○		
#4	82.3		
#7	76.8		
#10	74.0		
#14	71.2		
#18	67.8		
#25	63.4		
#35	56.4		
#45	46.7		
#60	32.6		
#80	16.4		
#120	8.9		
#170	6.4		
#230	5.5		

SOIL DESCRIPTION

○ LIMESTONE, sandy, medium to fine quartz, light brown- tan

REMARKS:

○ Sample split on 1/2

○ Source: TP-VKDA-1   Sample No.: 1B (Bulk)   Elev./Depth: +24.8'

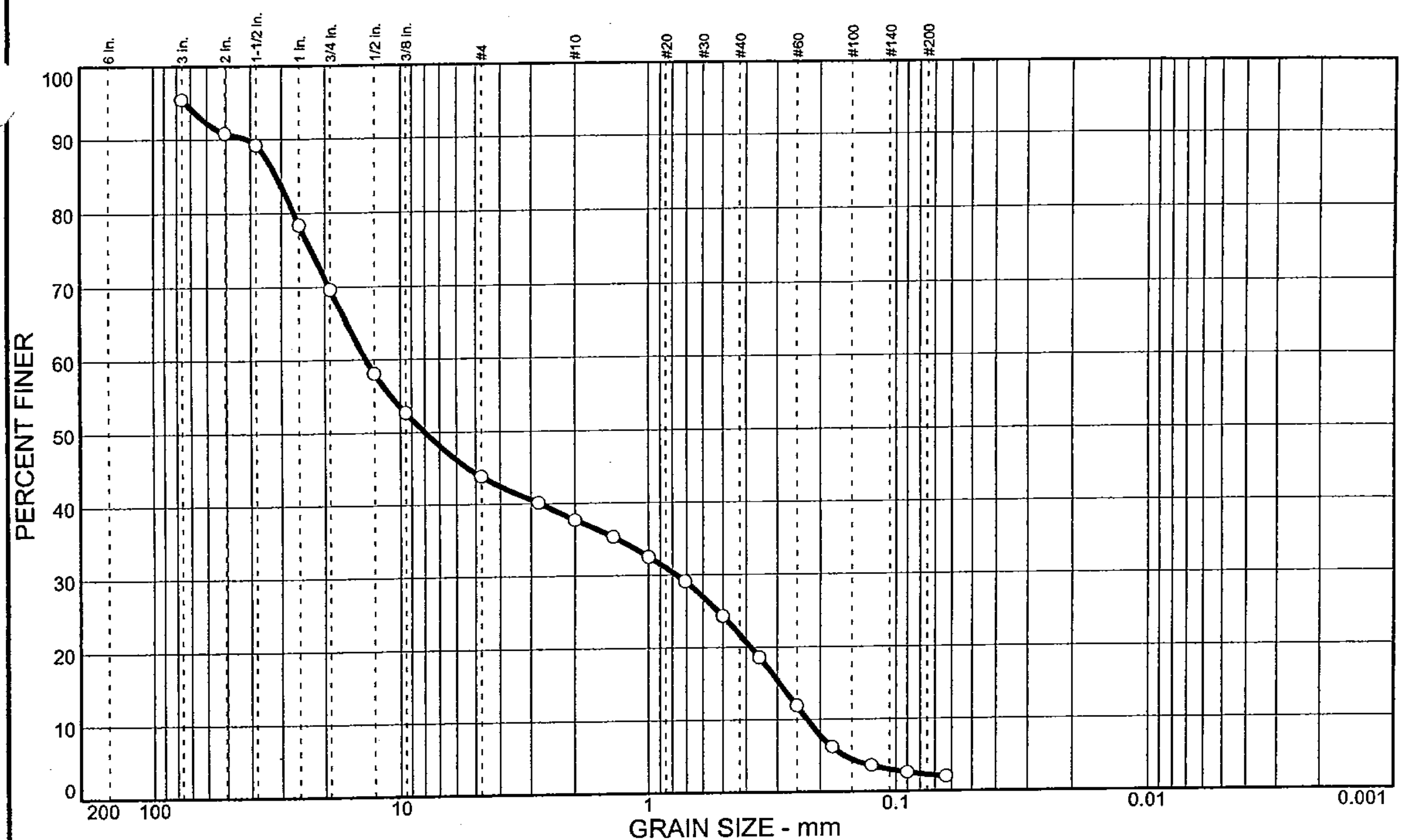
Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07   Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
○	4.6	51.6	41.5	2.3		GP	A-1-a		

SIEVE inches size	PERCENT FINER ○		
3	95.4		
2	90.8		
1.5	89.2		
1	78.4		
.75	69.7		
.50	58.1		
.375	52.7		
	GRAIN SIZE		
D_{60}	13.7		
D_{30}	0.770		
D_{10}	0.227		
	COEFFICIENTS		
C_c	0.19		
C_u	60.45		

SIEVE number size	PERCENT FINER ○		
#4	43.8		
#7	40.1		
#10	37.7		
#14	35.3		
#18	32.5		
#25	29.1		
#35	24.3		
#45	18.6		
#60	11.9		
#80	6.2		
#120	3.6		
#170	2.6		
#230	2.0		

SOIL DESCRIPTION

○ LIMESTONE, sandy, medium to fine quartz, little sand sized shell fragments, light brown-tan

REMARKS:

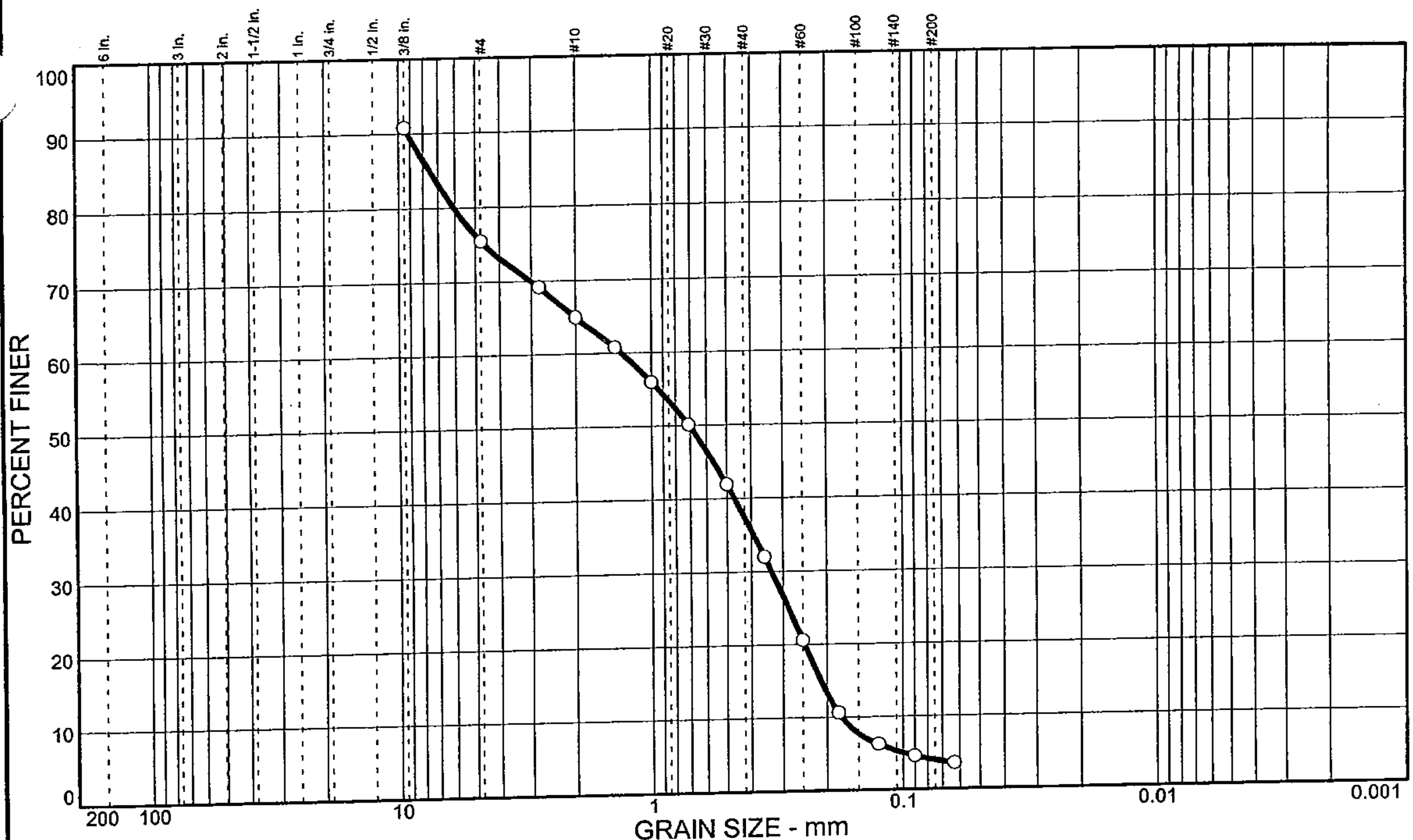
○ Percent Carbonate: 84%
Visual Percent Shell: 20%

○ Source: TP-VKDA-2 Sample No.: 1A (Bulk) Elev./Depth: +24.9'

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District
Project: Virginia Key
Project No.: 40521-1-8482-07 Plate

Particle Size Distribution Report



	% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY	USCS	AASHTO	PL	LL
O			71.6	3.9		SP	A-1-b		

SIEVE inches size	PERCENT FINER O		
3/8	90.8		
	GRAIN SIZE		
D_{60}	1.32		
D_{30}	0.333		
D_{10}	0.175		
	COEFFICIENTS		
C_c	0.48		
C_u	7.52		

SIEVE number size	PERCENT FINER O		
#4	75.5		
#7	69.2		
#10	64.9		
#14	60.8		
#18	56.0		
#25	50.1		
#35	41.9		
#45	32.0		
#60	20.6		
#80	10.6		
#120	6.2		
#170	4.5		
#230	3.5		

SOIL DESCRIPTION

O LIMESTONE, sandy, medium to fine quartz, light brown- tan

REMARKS:

O Sample split on 1/2

O Source: TP-VKDA-2

Sample No.: 1B (Bulk)

Elev./Depth: +24.9 Feet

Law Engineering and Environmental Services, Inc.

Client: USACE, Jacksonville District

Project: Virginia Key

Project No.: 40521-1-8482-07

Plate

HISTORICAL SHORELINE CHANGES

VIRGINIA KEY, DADE COUNTY, FLORIDA

The period of record for the study of shoreline changes on Virginia Key begins with the 1851 survey by the United States Coast and Geodetic Survey (H.D. No. 561/87/2). A similar survey in 1867 indicated that the shoreline of Virginia Key had remained relatively stable during that 16 years. A 1913 survey established shorelines north and south of but not on Virginia Key. The 1919 survey reveals that the most drastic shoreline changes during the period of record had occurred since the 1867 survey. It was during that period that the entrance to Miami Harbor was constructed, complete with protecting jetties, about 1 mile to the north of the island.

The preliminary examination to determine the most feasible location for an improved entrance into Miami Harbor was made in 1895. The pertinent physical aspects of the general area are provided in the annual report of the Chief of Engineers, U. S. Army, as follows:

"Communication is had with Biscayne Bay.......through the passages just under Cape Florida--Bear Cut and Norris Cut.

"Norris Cut is the most northerly of these entrances and is the first to separate the Keys from the mainland. It is about one-quarter of a mile in width and has upon its bar at low water about 4 feet........ within the cut and in the shoal inside, there is a narrow channel about a mile in length having a depth from 6 to 8 feet. The water then shoals up and for the next 2 miles, going toward the interior of the bay, there is an average depth of about 3 feet......the best water to be found within the bay and a range of 3 miles from the mouth of the cut does not exceed 8 feet.

"Bear Cut is 1.5 miles to the southward of Norris Cut, and separated from it by a low island called Virginia Key. It is about one-half mile in width, and has upon its bar a low water of 4 feet.......

"From the bar there is a narrow channel, about 3 miles in length leading into the bay. Through this 10 feet could be carried with very little improvement of its present condition into the bay, where the same depth is found."

The project adopted by the River and Harbor Act of June 13, 1902, provided for a channel 18 feet deep from the wharves at Miami to the ocean by way of a line entering the sea at a point about 4,000 feet north of Norris Cut. Operations by the United States were commenced 15 March 1904. At the end of the fiscal year the breakwater had been built of coral rock to a length of 1,080 feet and to the average height of mean low water, to form the core and foundation for the proposed breakwater.

On 30 June 1905 the foundation and core of the breakwater had been built to a distance of 1,400 feet from shore. The breakwater was capped with granite to a height of 5 feet above mean low water for a distance of 1,150 feet from shore. At that time the sides of the seaward end of the cut were being rapidly eroded by wave action, forming a widely diverging shoreline at the entrance. The sand removed by this erosion was being deposited seaward of the entrance, forming a shoal with only 3 feet of water over it at mean low water, where a depth of as much as 8 feet had previously existed.

By 13 January 1906 the shoreward end of the north jetty--the south jetty remained as deferred construction--required protection from erosion by construction of a revetment along the oceanshore north of the jetty, and the uncapped portion of the jetty (Station 1,150 to 1,400) had been lowered by storms from 1 to 10 feet below mean low water. In 1907 dredging work commenced at the start of the year but was discontinued in August after it was found that the dredged cut filled in as fast as it could be excavated.

On 3 December 1907 work commenced on the construction of the south jetty. At the end of the fiscal year about 21,000 cubic yards of local limestone for core and foundation had been placed in the south jetty. Under the influence of the jetties the littoral drift of the sand was checked and that which had accumulated in the dredged channel had begun to scour. The jetties were completed in October 1908 and channel dredging resumed.

In June 1912 it was reported that since completion of initial work no practicable channel had been secured, as the channels dredged had filled up at the outer ends within a few months after their completion. Work for the fiscal Year obtained depths of 18 to 19 feet with a channel width of 110 feet. The channel filled to the original depth by June 1912. The controlling depth in June 1916 was 7 feet. In 1916 the channel had all rock removed down to 20 feet below mean low water.

The most severe erosion experienced on Virginia Key due to construction of the Federal Navigation Project at Government Cut was in the middle of the key where the shoreline receded as much as 1,460 feet during the period of record. As seen from the attached plate 3 from the cooperative beach erosion study about 1,000 feet of the recession along the eastern shore occurred prior to 1919 and after the 1867 survey. The accelerated recession presumably occurred during the 15-year period from 1904 to 1919. The erosion continued at a rapid rate through 1927 at the northeast end and at the middle of the island with the remaining shoreline showing indications of reaching a generally stable shoreline.

The 1935 survey indicates that the shore had eroded to about its present position except at the northeast tip of the island which did not recede to its present position until about the time of the 1945-47 survey. The relatively stable shoreline attained about 40 years after construction of Government Cut, an almost complete littoral barrier, is attributable to a combination of a small quantity of littoral material reaching the island across Government Cut and the relatively shallow limestone formations offshore east of the key. Core borings obtained during a search for offshore borrow areas in late 1967 indicate a limestone formation with a rather level top located about 6 feet below mean low water. As seen on the attached plate the 6- and 12-foot contours have remained in the same general area during the period of record due to the presence of the rock bottom. Available aerial photographs indicate that the offshore shallows effectively dampen wave energy along the eastern shore of the island.

Aerial photographs taken in April 1940 and March 1952 indicate very little change in the island shoreline during that period and that a small beach existed on the northeast tip of the island in 1952. In the 6-year period from 1952 to June 1958--the date of the next aerial photographs of record--various dredge and fill operations in the immediate area of Virginia Key subsequently effected a change in the littoral regime along the island's ocean shoreline. As indicated on the attached plate dredge permits were approved for obtaining fill from Norris Cut for construction of a sewage treatment facility on Virginia Key. The quantity of material to be removed from the cut and the bay immediately inside of the cut was estimated at 1.08 million yards. The borrow areas provided under permits 8974 and 9545 were dredged about 1954-55. The exact quantities of fill removed from the two areas are not available. Minor excavation was performed to install the sewage outfall line during the same period. The borrow area in the bay of the west end of the island and in the bay entrance to Bear Cut (Permit 9996) was also dredged about 1954-55. The estimated quantity of fill material to be removed was 0.3 million cubic yard.

The effect of the dredging in Norris Cut on the northeast end of the island was apparent in aerial photographs as early as June 1958. The littoral material that had been moving south across the shallows of Norris Cut to nourish the Virginia Key beaches began to appear as shoaling in the dredged channel located across the bay entrance to the cut. The dredged channel also changed the tidal currents into Norris Cut with increased velocities close inshore on the northeast end of the island sweeping sand off the beaches on that part of the island and into the dredged channel.

The effect of dredging in Bear Cut on Virginia Key was reflected in efforts by local interest in 1956 to rebuild and lengthen a few groins constructed along the south shore in 1948 and to build new groins, bringing the total number of groins in the field to 27. The groins are approximately 50 feet long and are spaced 50 to 150 feet apart. The top of the groins is at elevation 4.5 feet above mean low water. The groins are distributed over a reach of shore approximately 2,700 feet long. The construction of the sewage outfall line on the east side of the island has resulted in increased wave energy reaching the shore in the area of the pipeline. Waves moving up the offshore pipeline cut diffract slightly upon reaching shore causing both northerly and southerly alongshore currents. A sheet pile wall left in place on the beach after construction of the pipeline is acting as an impermeable groin in the diffracting wave climate with unusually severe erosion occurring on the south side of the wall.

The accelerated erosion that occurred after the extensive dredging operations in the mid-1950's led to the cooperative study initiated by application of the city of Miami dated 15 October 1958. In the study leading to the ensuing Federal Beach Erosion Control Project the District Engineer recommended construction of a protective and recreational beach for 1.8 miles of beach on Virginia Key (see H.D. No. 561/87/2, page 22). The estimated volume of material required for initial fill was 650,000 cubic yards. The average annual loss rate from the eastern shore of Virginia Key south to about the bridge connecting the two islands was about 80,000 cubic yards over the entire length of profile surveyed, and about 30,000 cubic yards over the inner part of the profile. That average annual loss was determined for the period 1919-1960 and was used to estimate the annual nourishment requirement of 30,000 cubic yards for the key. Groins were also recommended for deferred construction by the District Engineer.

The Beach Erosion Board, in reviewing the study, concluded that periodic beach nourishment was the most suitable and economical remedial measure in the problem areas and recommended Federal participation in the cost of projects therefor at these locations, subject to local cooperation. The plans proposed by the Board provides in part for periodic nourishment of 1.8 miles of Virginia Key and for deferred construction of three groins on the key. The Board considered that to maintain the position and dimensions of the present beaches, the future annual nourishment requirements should be based on the average annual losses indicated over the entire length of profile surveyed, or about 80,000 cubic yards annually.

It is pertinent to point out that the computed average annual loss was determined over a period of time when natural bar bypassing across Norris Cut was providing sufficient littoral material to maintain a quasi-steady rate of beach erosion on Virginia Key. That quantity of material entering the area across Norris Cut cannot be determined. However, the material being lost into the dredged area of the cut is visible as shoaling in recent aerial photographs. The loss into the cut of the heretofore naturally bypassed littoral material will increase the quantity of fill required as nourishment to protect existing beaches on the key.

In implementing the Federal project the initial estimated amount to be provided was 160,000 cubic yards for Virginia Key and 130,000 cubic yards for Key Biscayne, representing a 2-year supply. The local sponsor would not provide local assurances if the project required dredging fill from Biscayne Bay and if the project adversely affected existing seawater intakes along the southerly end of Virginia Key. Suitable fill material was not available offshore from Virginia Key, but sufficient quantities for both areas were found offshore from Key Biscayne. The required material for Virginia Key was trucked to that shore. The problem with the intakes was hopefully resolved by omitting fill along the southerly end of Virginia Key in the vicinity of the pipes. The Board of County Commissioners furnished satisfactory assurances of local cooperation.

A contract to accomplish the project was awarded 20 November 1968. It was for placement of 180,000 cubic yards of fill at Virginia Key and 120,000 cubic yards at Key Biscayne at a total cost of $476,600. Construction was completed and the work accepted in July 1969.

The beach on Virginia Key did not reach stability, with certain areas showing erosion, shortly after the fill operation was complete. The Chief Engineer for Metropolitan Dade County reported by letter of 4 June 1970 that several reaches of the fill were severely eroding. He requested that a review be made of the need for groins, as well as additional sand nourishment. The Miami Beach Resident Engineer visited the Virginia Key beach nourishment site and reported on 1 July 1970 that severe erosion had removed all fill from certain reaches of beach.

A CERC-sponsored study by the University of Florida to monitor behavior of the beach fill on the two islands was initiated in late summer of 1970 with profile surveys on Virginia Key obtained in late September 1970. The study is not complete; however, the profiles obtained indicate three distinct erosion problems existing on the island.

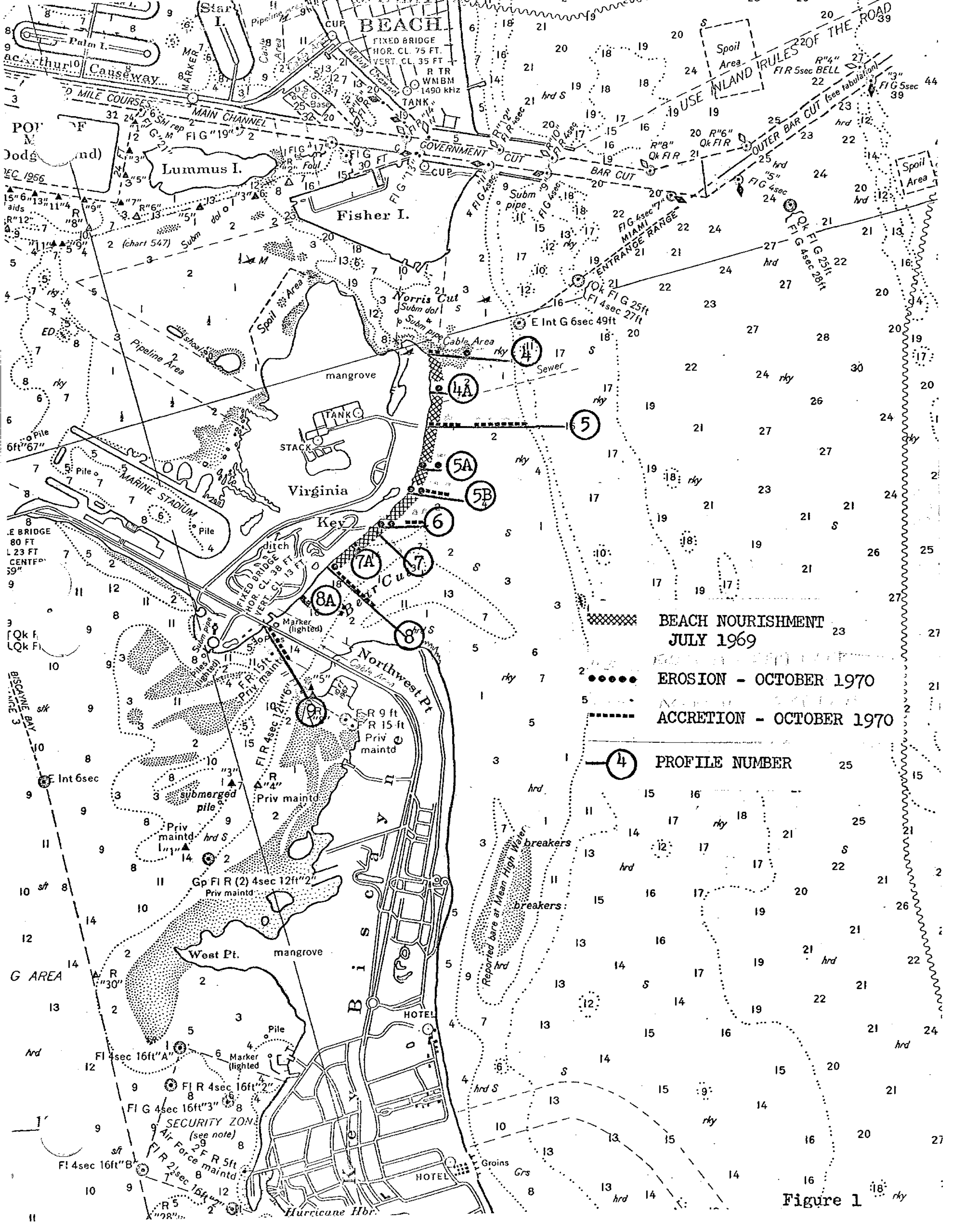
The first is on the northeast end of the island where tidal currents moving into Norris Cut are moving beach material around the end of the island to be lost in the shoals forming in the channels dredged in the mid-1950's. Future dredging in Norris Cut, for which a permit has been issued (see attached figure 1) will contribute significantly to the erosion problem on the north end of Virginia Key. A groin field with groins of varying lengths and initial fill is necessary along the northernmost 1,300 feet of the island (profiles 4 and 4A) to prevent further loss of land and to protect the nourished beach to the south.

The second problem area is in the vicinity of the sewage outfall line, particularly to the south of the sheet pile retaining wall. Defracting waves striking the shore at the pipeline move beach material both north and south, especially to the south where the material cut from the beach between profiles 4A and 5 is moved south and offshore along profile 5. A groin is needed to stabilize the beach alinement south of the pipeline. The shore at profile 5 appears to be a nodal point in the littoral process along the island shore. As seen in the attached sketch the beach and offshore bottom accreted while profiles, both north and south, show evidence of erosion.

The third problem area is the reach of shore from about profile 5A to profile 6. Littoral processes in that particular reach is influenced by tidal currents moving into Bear Cut. Aerial photographs of the island taken during a wave climate, estimated from the photographs of offshore swells with a period of 9 to 10 seconds, clearly indicate that the bottom material placed in suspension by the wave action is moved toward Bear Cut. The apparent dividing line for the tidal flow into Norris Cut and Bear Cut is in the general vicinity of the sewage outfall line. Tidal current velocities in the reach between profiles 4A and 5A, however, are believed to be nominal.

A refraction diagram, which is at best an estimate of wave energy concentrations along perfectly alined shorelines, would be of nebulous value due to the offshore shallows and the presence of the two inlets. All available photographs, in which wave action is evident, show significant wave forces first influencing the southeast shoreline in the area of profile 5A. The combined effect of tidal currents and wave action on the reach from profile 5A to profile 6 is evident in comparison of postconstruction surveys and the University of Florida surveys in September 1970, which indicate that much of the nourishment material in that reach is moving offshore and into the center of Bear Cut. Accretion is evident in the cut from profiles 8 through 9. The September surveys did not include profile 7; however, the general trend of offshore accretion from profiles 5B to 9 indicate that accretion could be expected along the outer end of that profile.

A groin field is required along the reach from north of profile 5B westerly to about profile 7A (about 2,600 feet) where the field will transition into the existing wooden groin field described above. The existing field is performing satisfactorily and particularly since the July 1969 nourishment program has trapped much material moving along the beach. The proposed groins would vary in length from about the length of the existing groins at the west end to about 400 feet long in the area of profile 5B. The groins would be of composite construction with the inner, or shoreward, end impermeable to maintain a protective beach. The outer end would be permeable to allow movement of a limited amount of nourishment material to the groin field to the west but would also affect a limited amount of wave dampening. The increased length of the groins in the area of profile 5B is required to swing the tidal currents offshore and retard the movement of nourishment material to the west into Bear Cut.



BEACH NOURISHMENT
JULY 1969
EROSION - OCTOBER 1970
ACCRETION - OCTOBER 1970
PROFILE NUMBER
4
4A
5
5A
5B
6
7
7A
8
8A
9
Virginia
Key
Fisher I.
Lummus I.
Norris Cut
Bear Cut
Northwest Pt
West Pt.
MARINE STADIUM
GOVERNMENT CUT
MAIN CHANNEL
MIAMI ENTRANCE RANGE
OUTER BAR CUT
USE INLAND RULES OF THE ROAD
Spoil Area
mangrove
breakers
Reported bare at Mean High Water
SECURITY ZONE
Hurricane Hbr
HOTEL
Groins

Figure 1

SECTION 111

SHORELINE STABILIZATION REPORT
AND
DRAFT ENVIRONMENTAL ASSESSMENT

VIRGINIA KEY
DADE COUNTY, FLORIDA

APPENDIX B

ECONOMICS

U.S. Army Engineer District
Jacksonville, FL

February 2002

ECONOMIC ANALYSIS
VIRGINIA KEY

PROJECT BENEFITS

Stablization of the beach at Virginia Key generate both primary and incidental benefits. The primary tangible benefits of this project include the prevention of loss of land. Incidental benefits generated by this project would be those generated by increased recreational usage.

This appendix includes detailed discussions of both primary benefits (i.e. storm damage prevention benefits) and incidental benefits (i.e. recreation benefits). Following those discussions, a summary of total project benefits and costs is provided.

Engineering Regulation 1105-2-100 (The Planning Guidance Notebook) provides economic evaluation procedures to be used in all Federal water resources planning studies. The guidelines specified in the ER 1105-2-100 dated 22 April 2000 were observed in preparing this report. The Federally mandated project evaluation interest rate of 6.125 percent, an economic period of analysis of 50 years and February 2002 prices were used to evaluate economic feasibility.

Loss of Land Benefits

To determine the value of stabilizing the shoreline and preventing the loss of land to recession, the market value of the average annual area expected to be lost is estimated.

The existing terminal groins have been deteriorating over times. Coastal engineers have estimated that the study area has lost at least an estimated 1,170 square feet of land per year for the last 50 years. With the proposed improvements in place the erosion rates would be minimal.

The fair market value is defined as the amount in cash or equivalent that the property would be sold for by a knowledgeable and willing owner to a knowledgeable and willing buyer. Engineering Circular 165-2-149 requires that market value be determined based upon the value of nearshore land. Nearshore land is defined in the Engineering Circular as "land that is sufficiently removed from shore to lose it's significant increment of value because of it's proximity to the shore, when compared to adjacent parcels that are more distant from the shore." A gross estimate of oceanfront and near-shore lands were made by analyzing vacant land sales in the project area by the Appraisal Branch of the Jacksonville District Real Estate Division in the June 1994. The reported market value assigned to near-shore land varied from $25.00 to $40.00 in Dade County. This estimate was reported as part of the Coast of Florida Erosion and Storm Effects study. Using a consumer price index (CPI) inflation factor of 1.19 the values could be between $30.00 to $48.00.

The average annual loss of land benefit could be expected to be between $35,100 and $48,100 annually. The average of the two or $41,600 will be used in this analysis.

Recreation Benefits

The national economic development (NED) benefit evaluation procedures contained in ER 1105-2-100 (22 Apr 00), Appendix E, Section VII, include three methods of evaluating the beneficial and adverse NED effects of project recreation: travel cost method (TCM), contingent valuation method (CVM), and unit day value (UDV) method.

The unit day value (UDV) method was selected for estimating recreation benefits of stabilizing and reopening the historic Virginia Key beach to users. When the UDV method is used for economic evaluations, planners will select a specific value from the range of values provided annually. Application of the selected value to estimate annual use over the project life, in the context of the with- and without-project framework of analysis, provides the estimate of recreation benefits. The without project condition in this analysis have no recreation value since the historic Virginia Key Beach Parks is closed to the public. The with-project condition will be the expected value of the recreational activity based on the UDV method. Table 1 illustrates the method of assigning a point rating to a particular activity. The table also shows the point values assigned based on measurement standards described for the five criteria of activities, facilities, relative scarcity, ease of access, and aesthetic factors.

Table 1: Guidelines for Assigning Points for General Recreation

Criteria	Judgment factors				
Recreation experience[1]	Two general activities[2]	Several general activities	Several general activities: one high quality value	Several general activities; more than one high	Numerous high quality value activities; some general

Total Points: 30 Point Value: 7	 0-4	 5-10	activity[3] 11-16	quality high activity 17-13	activities 24-30
Availability of opportunity[4] Total Points: 18 Point Value: 2	Several within 1 hr. travel time; a few within 30 min. travel time 0-3	Several within 1 hr. travel time; none within 30 min. travel time 4-6	One or two within 1 hr. travel time; none within 45 min. travel time 7-10	None within 1 hr. travel time 11-14	None within 2 hr. travel time 15-18
Carrying capacity[5] Total Points: 14 Point Value: 7	Minimum facility for developmen t for public health and safety 0-2	Basic facility to conduct activity(ies) 3-5	Adequate facilities to conduct without deterioration of the resource or activity experience 6-8	Optimum facilities to conduct activity at site potential 9-11	Ultimate facilities to achieve intent of selected alternative 12-14
Accessibility Total Points: 18 Point Value: 13	Limited access by any means to site or within site 0-3	Fair access, poor quality roads to site; limited access within site 4-6	Fair access, fair road to site; fair access, good roads within site 7-10	Good access, good roads to site; fair access, good roads within site 11-14	Good access, high standard road to site; good access within site 15-18
Environmental Total Points: 20	Low esthetic factors[6] that significantly lower quality[7]	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality

Point Value: 5	0-2	3-6	rectified 7-10	11-15	16-20

Table 2. Conversion of Points to Dollar Values

Point Values	General Recreation Values (1)
0	$2.82
10	3.35
20	3.70
30	4.23
40	5.29
50	6.00
60	6.52
70	6.88
80	7.58
90	8.11
100	8.46

Table 2 was used to convert points to a UDV FY2001 dollar amount. The 34 points resulted in a user day value of $4.65. The next step is to estimate the annual use over the project life.

The State of Florida's Department of Environmental Protection's Division of Recreation and Parks coordinated and developed the Draft Florida Statewide Comprehensive Outdoor Recreation Plan (SCORP) for 2000. This information was used to derive and project total salt-water beach participation and allocate this participation from state to regional levels. The south Florida region (Region 11) includes Broward, Dade, and Monroe counties. The current SCORP indicates demands not met for salt water beach activities based on supply, resource, and facility use guidelines which represent carrying capacities condition for the resource.. For the south Florida region an additional 8 miles of resources for salt-water beach participation were required for 1997, 14 miles for 2000, 25 miles for 2005 and 36 miles for 2010. It is felt that there is sufficient demand for salt-water beach activities that opening this area will not detract of other areas in the vicinity.

A turnover rate of two is utilized to account for the fact that the average beach visitor uses the beach for only one-half of a day, usually in the morning or in the afternoon. This means that twice the effective beach area and twice the effective parking capacity is available during a given day. Daily automobile counts for two years were analyzed for cars entering Crandon Beach just to the south of historic Virginia Key. It was discovered that 60 percent of total visitation occurred on the weekend days and 40 percent of total visitations were on weekdays. The analysis of the Crandon Beach data showed that attendance on weekdays was 25.6 percent of the weekend days. Assuming the Historic Virginia Key has a capacity of 1100 persons per day at 2.75 persons per car (SCORP 2000) there would be 187,944 user occasions at $4.65 per user occasion for a total of $873,942 annually

Total Project Benefits and Costs

The tangible economic justification of the proposed project can be ascertained by comparing the equivalent average annual charges (i.e., interest, amortization, periodic nourishment, and other maintenance costs) with an estimate of the equivalent average annual benefits, which would be realized over the 50-year period of analysis. These average annual benefits and costs are summarized in Table 3.

Table 3

Summary of Costs and Benefits

Initial Construction	$1,491,030
Interest during PED and Construction	62,480
Total Investment	$1,553,510
Annual Cost	
Interest and Amortization	$100,280
O&M cost	14,640
Total Annual cost	$114,920
Recreation Benefits	$873,940
Loss of Land Benefits	41,600
Total Annual Benefits	$915,540
Net Benefits	$800,620
Benefit to cost Ratio	8.0 to 1

Assumptions:
Present worth of all maintenance is $226,730.

PED takes 4 months and cost $300,000.

Construction cost evenly distributed over 12 months.

3 months delay between end of PED and construction start.

Initial Construction cost includes $28,125 in Real Estate Cost.

SECTION 111

SHORELINE STABILIZATION REPORT
AND
DRAFT ENVIRONMENTAL ASSESSMENT

VIRGINIA KEY
DADE COUNTY, FLORIDA

APPENDIX C

REAL ESTATE

U.S. Army Engineer District
Jacksonville, FL

February 2002

TABLE OF CONTENTS

1. **Statement of Purpose.**

The purpose of the Real Estate Plan for Virginia Key Shoreline Stabilization is tentative in nature for planning purposes only and both the final real property acquisition line and real estate cost estimates provided are subject to change even after approval of the Shoreline Stabilization report.

2. **Project Authorization.**

a. Study authorized provided by the US Senate and House of Resolution dated December 5, 1980 and September 23,1982.

b. Coast of Florida Erosion and Storm effects study was authorized by Section 104 of PL 98-360 and by Resolution passed by the Committee on Public Works and Transportation, US House of Representative dated 8 August 1984.

c. Federal Shore Protection Project for Virginia Key and Key Biscayne is authorized by the 1962 River and Harbor Act.

3. **Project Location.**

Virginia Key is a barrier island located along Eastern Biscayne Bay on the Atlantic coast of Dade County Florida, South of Miami Beach and North of Key Biscayne. Virginia Key is in Florida(s) 17^{th} Congressional District.

4. **Project Description.**

The recommended plan provides for the reconstruction of 24 existing Timber Groins, the construction of three new Timber Groins along the shoreline of Virginia Key, and removing the unnecessary structures. This proposed plan also involves the placement of approximately 5,000 cubic yards of beach quality material on an area of approximately 1300 feet long to nourish the critically eroded shoreline.

5. **Real Estate Requirements.**

Access to the project will be by sea, public streets and a public park owned by the City of Miami Beach. Temporary Work Area Easement will be provided by the Sponsor, the City of Miami. The required areas are: Stockpile area-1(11.3 acres), Borrow area-1(3.7acres), Stockpile area-2(9.3 acres)and Borrow area-2,(1.5 acres). Additionally, land along the beach (1,300 feet) above and below the mean high water will be required. All project lands are either below mean high water or publicly owned lands available at no cost to the Government.

6. **SPONSOR OWNED LANDS.**

a. Federal

There are no Federal owned lands associated with this project.

b. Non-Federal

The lands within the proposed project are owned by the City of Miami and the State of Florida.

7. **ESTATES.**

a. Standard Estates

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos.___,___and ___), for a period not to exceed five (5) years, beginning with date possession of the land is granted to the City of Miami, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon)(move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the_______________Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

b. Non-Standard Estate

There are no Non-Standard Estates required for project construction.

8. NAVIGATION SERVITUDE.

Navigation servitude will be exercised over the land below the mean high water level for construction of the groins and placement of beach quality material.

9. PROJECT MAP.

A Project map is provided following this appendix.

10. INDUCED FLOODING.

There will be no induced flooding directly associated with this project.

11. REAL ESTATE BASELINE COST ESTIMATE.

Lands and Damages:

	$ 0
Total Lands and Damages (Rounded)	$ 0

Acquisition/Administrative Costs

Federal	
Project Planning	$10,000
Review of Acquisitions	$ 2,000
Total Federal Acquisition/ Admin Costs	$12,500
Non-Federal	
Acquisitions	$10,000
Total Non-Federal Acquisition/ Admin Costs	$10,000
Contingencies (25%) (Rounded)	$ 5,625
Total Estimated Real Estate Costs (RD)	$28,125

*Contingencies of 25% are estimated to cover uncertainties associated with land certification.

12. RELOCATION ASSISTANCE BENEFITS (Public Law 91-646).

No person(s)or business(s) will require relocation.

13. MINERALS.

No known minerals exist in the proposed project area.

14. Non-FEDERAL SPONSOR'S AUTHORITY TO PARTICIPATE.

The City of Miami is empowered by Chapter 10847, Section 3(f,g). Such powers include the authority to make contracts and enter into agreements, to acquire and hold lands and property by any lawful means, to exercise the power of eminent domain, and to construct, acquire, operate and maintain shore protection works and facilities. The City of Miami has the authority to tax property or issue bonds to meet the costs of the city beach and shore preservation program.

15. REAL ESTATE MILESTONES.

There is no scheduled acquisition of real estate.

16. RELOCATIONS OF ROADS, BRIDGES, UTILITIES, TOWN AND CEMETERIES.

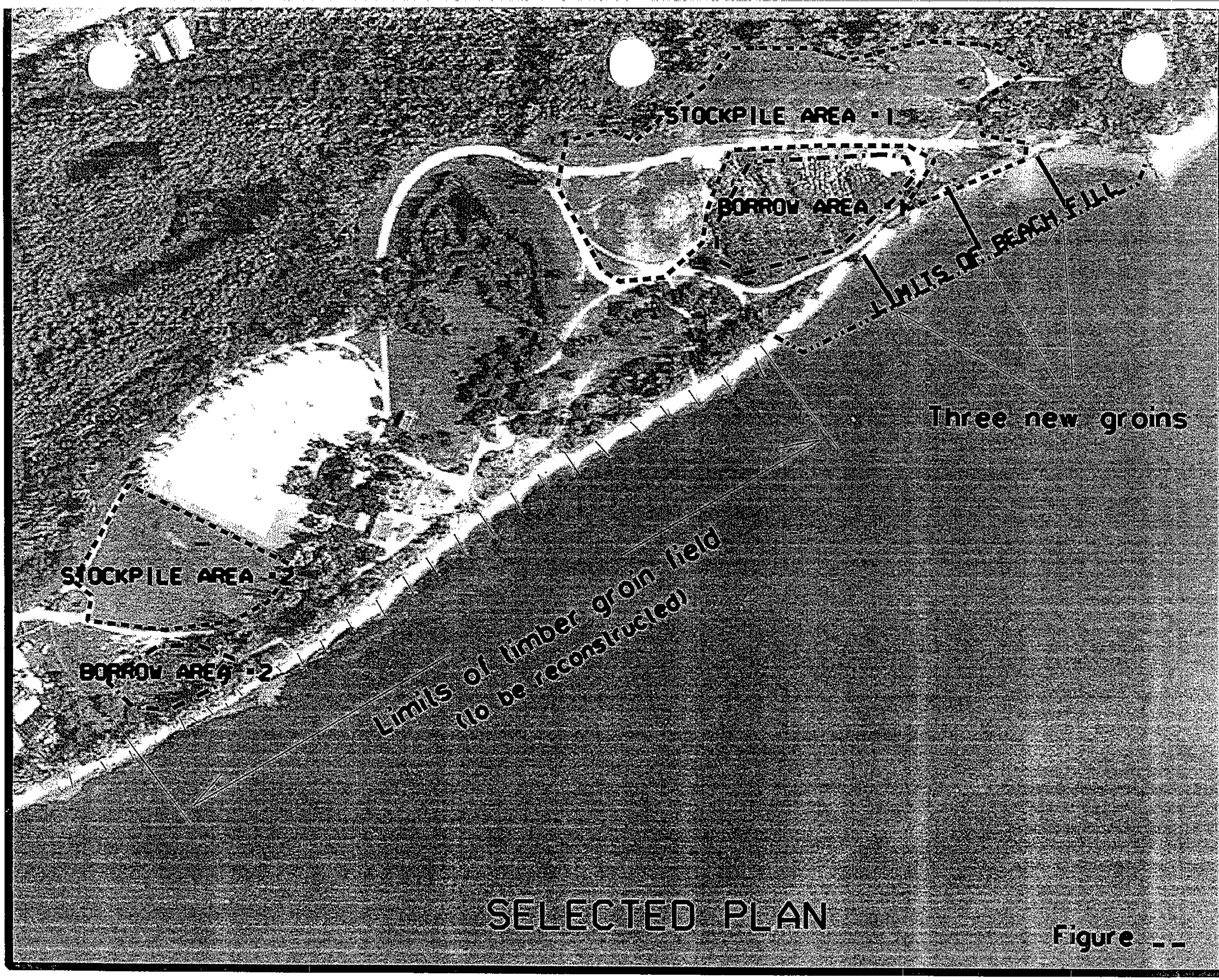
There are no known utilities, roads, highways or railroads that will require relocation.

17. PRESENCE OF CONTAMINANTS (HAZARDOUS, TOXIC AND RADIOACTIVE WASTES).

A site audit for hazardous, toxic and radioactive waste material was performed by Jacksonville District, Environmental Branch with negative results. The site audit includes a site visit and research of historical data.

18. ATTITUDE OF LANDOWNERS.

The propose project lands are owned by the State of Florida and the City of Miami. The owners are supportive of the proposed project.


STOCKPILE AREA - 1
BORROW AREA - 1
LIMITS OF BEACH FILL
Three new groins
STOCKPILE AREA - 2
BORROW AREA - 2
Limits of timber groin field
(to be reconstructed)
SELECTED PLAN
Figure _ _

SECTION 111

SHORELINE STABILIZATION REPORT
AND
DRAFT ENVIRONMENTAL ASSESSMENT

VIRGINIA KEY
DADE COUNTY, FLORIDA

APPENDIX D

CORRESPONDENCE

U.S. Army Engineer District
Jacksonville, FL

February 2002

DIVISIONS OF FLORIDA DEPARTMENT OF STATE
Office of the Secretary
Office of International Relations
Division of Elections
Division of Corporations
Division of Cultural Affairs
Division of Historical Resources
Division of Library and Information Services
Division of Licensing
Division of Administrative Services

FLORIDA DEPARTMENT OF STATE
Katherine Harris
Secretary of State
DIVISION OF HISTORICAL RESOURCES

January 17, 2002

Mr. James C. Duck
Planning Division, Environmental Branch
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32399-0250

RE: DHR Project File Number: 2002-00095
Received by DHR: January 11, 2002
Project: Virginia Key Beach Restoration Project / Miami, Dade County, Florida

Dear Mr. Duck:

Our office has received and reviewed the above referenced project in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*. The State Historic Preservation Officer (SHPO) is to advise and assist federal agencies when identifying historic properties (listed or eligible for listing, in the National Register of Historic Places), assessing effects upon them, and considering alternatives to avoid or reduce the project's effect on them.

Based on the information provided in the referenced project, and our review of the *National Register of Historic Places* nomination proposal, and the Florida Master Site file for 8DA6, we concur with the evaluation that the restoration of Virginia Key Beach and its related structures will have no adverse effect on any historic properties.

If there are any questions concerning our comments, please contact Allison McCarthy, Historic Sites Specialist, by electronic mail at amccarthy@mail.dos.state.fl.us or at 850-245-6333 or 800-847-7278. Thank you for your interest in protecting Florida's historic properties.

Sincerely,

Jan Matthews

Janet Snyder Matthews, Ph.D., Director, and
State Historic Preservation Officer

JAN 10 2002

Planning Division
Environmental Branch

Dr. Janet Snyder Matthews
Director, Division of Historical Resources
State Historic Preservation Officer
500 South Bronough Street
Tallahassee, Florida 32399-0250

Dear Dr. Matthews:

The U.S. Army Corps of Engineers (Corps), Jacksonville District, is studying the environmental effects of the proposed Virginia Key Beach Restoration Project. The project is located on the Atlantic Coast of Virginia Key in eastern Dade County, specifically in sections 16, 20 and 21 of Township 54 South Range 42 East illustrated on the Key Biscayne NW USGS Quad map. The project consists of renourishing the critically eroded Virginia Key Beach. The project is located in the historic Virginia Key Park. This was Miami's former "Colored Beach" which was one of the few places that African-Americans could go to swim in Miami from the 1940s through the 1960's. A National Register of Historic Places nomination has been completed identifying the Virginia Key Park as eligible because of its association with events that have made a significant contribution to broad patterns of our history.

The project is to place beach quality sand from existing spoil piles on the island onto the beach. It also includes the replacement of the deteriorated wooden groins in the historic beach area. According to the 2001 National Register nomination, these were constructed around 1953. Even though the beach was the focus of the park and the groins served to stabilize the beach, they are not identified as contributing elements to the National Register property. Because of their deteriorated condition, the Corps proposes to replace them in kind. A prehistoric site (8DA6) has been reported on the north end of the island. The beach fill will not occur in the vicinity of this reported site. A cultural resource survey was conducted by the Archaeological and Historical Conservancy for the Virginia Key Beach Park Trust. Other than the historic park, no other cultural resources were located.

Since the wood groins were not identified as contributing elements to the National Register site, their replacement will have no effect on the historic site. The beach fill will alter the existing condition; however, this will restore the historic condition and will be a beneficial and not adverse effect. Based on this evaluation, I request your concurrence with my determination of no adverse effect to historic properties effected for the Virginia Key Restoration Project. If there are any questions, please contact Mr. Grady Caulk at 904-232-1786 or by e-mail at grady.h.caulk@saj02.usace.army.mil.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosures

March 21, 2001

Mr. James C. Duck
Department of the Army
Jacksonville District Corps of Engineers
Attn: Planning Division
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: Department of the Army - District Corps of Engineers - Study to Evaluate Alternatives for Shoreline Stabilization - Virginia Key Beach Park - Miami-Dade County, Florida
SAI: FL200102010041C

Dear Mr. Duck:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The South Florida Water Management District (SFWMD) notes that, under the operating agreement between the Department of Environmental Protection (DEP) and the SFWMD, this project will be reviewed by DEP. DEP notes that its letter of August 31, 2000 (attached) related to the expedited reconnaissance study for this project is still valid. DEP would like to review the project proposed when there is sufficient detail in order to offer recommendations regarding design, construction and protection of the environmental resources in the area. Please refer to the enclosed SFWMD and DEP comments and attachment.

Based on the information contained in the application and the enclosed comments provided by our reviewing agencies, the state has determined that, at this stage, the above-referenced project is consistent with the Florida Coastal Management Program (FCMP). All subsequent environmental documents prepared for this project must be reviewed to determine the project's continued consistency with the FCMP. The state's continued concurrence with the

Mr. James C. Duck
March 21, 2001
Page Two

project will be based, in part, on the adequate resolution of issues identified during this and subsequent reviews.

In addition, the South Florida Regional Planning Council (SFRPC) has identified the policies and goals of its Strategic Regional Policy Plan which may apply to the proposed activity. The comments provided by the SFRPC are enclosed for your review and consideration.

If you have any questions regarding this letter, please contact Ms. Cherie Trainor, Clearinghouse Coordinator, at (850) 414-5495.

Sincerely,

Shirley W. Collins
Joseph F. Myers, Acting Executive Director
Florida Coastal Management Program

JFM/cc

Enclosures

cc: Robert Hall, Department of Environmental Protection
Jim Golden, South Florida Water Management District
Eric Silva, South Florida Regional Planning Council

Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

David B. Struhs
Secretary

March 2, 2001

Ms. Cherie Trainor
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

Re: Department of the Army District Corps of Engineers, Study to Evaluate Alternatives for Shoreline Stabilization, Virginia Key Beach Park, Miami-Dade County

SAI: FL200010201004lC

Dear Ms. Trainor:

Our letter of August 31, 2000 related to the expedited reconnaissance study for this project are still valid. We would like to review the project proposal when there is sufficient detail on which to make meaningful recommendations for design, construction and protection of the environmental resources in the area.

Thank you for the opportunity of commenting on this proposal. If you have any questions regarding this letter please give me a call at (850) 487-2231.

Sincerely,

Robert W. Hall
Office of Intergovernmental
Programs

Attachment

2001

State of Florida Clearinghouse

re:
FILE COPY

Department of Environmental Protection

Jeb Bush
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

David B. Struhs
Secretary

August 31, 2000

Ms. Cherie Trainor
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

Re: Department of the Army, District Corps of Engineers, Section 905(b) Expedited Reconnaissance Study, Shore Protection and Environmental Restoration, Virginia Key Beach Park, Miami-Dade County

SAI: FL20007310528C

Dear Ms. Trainor:

This Department has reviewed the above-described project proposal and based on the information provided, we submit the following comments and recommendations.

Comments:

Virginia Key Beach Park possesses a unique array of plant species within its beachfront dune, coastal strand, marine hardwood hammock and mangrove wetland communities. The Florida Natural Areas Inventory (FNAI) lists several rare plants found on the Key, including Biscayne prickly ash, the broad-leafed spider lily, the burrowing four-o'clock the necklace pod, and the sea lavender (see attached FNAI report dated August 10, 2000). Virginia Key Beach also provides important habitat for several species of shorebirds including the following threatened or endangered species: peregrine falcon, bald eagle, piping plover, and the roseate spoonbill. A gopher tortoise has also been observed at the site.

The study proposal lists potential shore protection and environmental restoration projects in conjunction with its site map. Additional details are needed on the alternatives being considered, in order to more accurately assess the potential benefits and impacts of this project. The beach has experienced significant erosion in this area, and since erosion has the potential to impact species whose dune habitat may be reduced or eliminated, a thorough evaluation of listed project alternatives would be desirable to include the following concerns:

1. Seagrass beds are plentiful in the study area and manatee observations are common in the nearby offshore waters of Virginia Key. Beach restoration efforts should address potential impacts to this resource.

2. Virginia Key Beach is a nesting area of the loggerhead sea turtle (caretta caretta). In 1994, the National Marine Fisheries Service documented 52 nests on the island. Shore protection efforts should consider compatibility with nesting sea turtles including the suitability of fill, if proposed.

3. A 1990 FNAI report indicated that most of the island is covered by a strand of Australian Pine (Casuarina equisetifolia). Any beach restoration should include removal of this exotic species, as its uprooting can contribute to accelerated beach erosion.

4. The proposed Restoration of tidal flow should be accompanied by an evaluation of alternatives for the disposal or placement of spoil material

5. Management requirements of the Biscayne Bay Aquatic Preserve are spelled out in Chapter 18-18, Florida Administrative Code. Special attention should be paid to Section 18-18.005, F.A.C., *General Management Criteria*, and Section 18-18.006, F.A.C., *Uses, Sales, Leases or Transfers of Interests in Lands or Materials Held by the Board.*

Recommendations:

In order to protect the shoreline from further erosion, staff recommends that the Corps explore either the restoration of existing timber groins, or the placement of riprap at or above the line of mean high water. It is felt that these alternatives would have the least impacts to wetland and submerged aquatic vegetation. The placement of riprap at or above the mean high water line would require an ERP regulatory permit and a Consent of Use for sovereignty, submerged lands. Other permits may be required depending on the alternatives selected. The department looks forward to working with the Corps and the community to develop a viable project.

Thank you for the opportunity of commenting on this proposal. If you have any questions regarding this letter please give me a call at (850) 487-2231.

Sincerely,

Robert W. Hall

Robert W. Hall
Office of Intergovernmental Programs

Attachment
cc: Anna Marie Hartman
David Mayer
Cheryl McKee
Jayne Bergstrom

COUNTY: Miami-Dade

DATE: 02/01/2001
COMMENTS DUE DATE: 03/02/2001
CLEARANCE DUE DATE: 03/16/2001
SAI#: FL200102010041

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State X Transportation	South Florida WMD	Environmental Policy/C & ED

RECEIVED
FEB 2001
State of Florida Clearinghouse

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - District Corps of Engineers - Study to Evaluate Alternatives for Shoreline Stabilization - Virginia Key Beach Park - Miami-Dade County, Florida.

To: **Florida State Clearinghouse**
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 922-5438 (SC 292-5438)
(850) 414-0479 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:

Division/Bureau: DOT

Reviewer: Sandra Whitmire

Date: 2/6/01

:OUNTY: Miami-Dade

DATE: 02/01/2001
COMMENTS DUE DATE: 03/02/2001
CLEARANCE DUE DATE: 03/16/2001
SAI#: FL200102010041C

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State Transportation	X South Florida WMD	Environmental Policy/C & ED

RECEIVED
FEB 05 2001
ERR - 4210

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

_ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

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_ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - District Corps of Engineers - Study to Evaluate Alternatives for Shoreline Stabilization - Virginia Key Beach Park - Miami-Dade County, Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 922-5438 (SC 292-5438)
(850) 414-0479 (FAX)

EO. 12372/NEPA

☐ No Comment
☐ Comments Attached
☐ Not Applicable

Federal Consistency

☐ No Comment/Consistent
☐ Consistent/Comments Attached
☐ Inconsistent/Comments Attached
☒ Not Applicable

UNDER THE OPERATING AGREEMENT BETWEEN DEP AND THE SFWMD, THIS PROJECT WILL BE REVIEWED BY DEP.

From:
Division/Bureau: ERR
Reviewer: JIM GOLDEN
Date: 2/5/01

COUNTY: Miami-Dade

DATE: 02/01/2001
COMMENTS DUE DATE: 03/02/2001
CLEARANCE DUE DATE: 03/16/2001
SAI#: FL200102010041

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State Transportation	South Florida WMD RECEIVED FEB 9 2001 State of Florida Clearinghouse	X Environmental Policy/C & ED RECEIVED FEB - 5 2001 OFFICE OF POLICY AND BUDGET ENVIRONMENTAL POLICY UNIT

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Project Description:

Department of the Army - District Corps of Engineers - Study to Evaluate Alternatives for Shoreline Stabilization - Virginia Key Beach Park - Miami-Dade County, Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 922-5438 (SC 292-5438)
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EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [ ] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:

Division/Bureau: OPB Env.

Reviewer: M Lonng

Date: 2/7/01

South
Florida
Regional
Planning
Council

RECEIVED
MAR 01 2001
State of Florida Clearinghouse

February 27, 2001

Ms. Cherie Trainor
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100

RE: SFRPC #01-0169, SAI # FL200102010041C – Response to a request for comments on a study to evaluate alternatives for shoreline stabilization, Department of the Army, Virginia Key, Miami-Dade County.

Dear Ms. Trainor:

We have reviewed the above-referenced project and have the following comments:

- Beaches and dune systems are identified as natural resources of regional significance in the *Strategic Regional Policy Plan for South Florida*. The use of groins and other hard coastal protection structures may adversely impact benthic resources and deprive downdrift shorelines of sand. Staff supports the use of buffer zones to protect these important resources. Sand movement and downdrift erosion should be monitored on a region wide basis to ensure the livelihood of wildlife habitats and the stability of renourished areas. All actions should be consistent with the goals and policies of the City of Miami comprehensive plan.

- Staff recommends that, if the proposed actions are implemented, 1) impacts to the natural systems be minimized to the greatest extent feasible and 2) the permit grantor determine the extent of sensitive marine life and vegetative communities in the vicinity of each project and require protection and or mitigation of disturbed habitat. These guidelines will assist in reducing the cumulative impacts to native plants and animals, wetlands and deep water habitat and fisheries that the goals and policies of the *Strategic Regional Policy Plan for South Florida* seek to protect.

- The goals and policies of the *Strategic Regional Policy Plan for South Florida*, in particular those indicated below, should be observed when making decisions regarding this project.

Strategic Regional Goal

3.1 Eliminate the inappropriate uses of land by improving the land use designations and utilize land acquisition where necessary so that the quality and connectedness of Natural Resources of Regional Significance and suitable high quality natural areas is improved.

3440 Hollywood Boulevard, Suite 140, Hollywood, Florida 33021
Broward (954) 985-4416, Area Codes 305, 407 and 561 (800) 985-4416
SunCom 473-4416, FAX (954) 985-4417, SunCom FAX 473-4417
e-mail sfadmin@sfrpc.com

Regional Policies

3.1.1 Natural Resources of Regional Significance and other suitable natural resources shall be preserved and protected. Mitigation for unavoidable impacts will be provided either on-site or in identified regional habitat mitigation areas with the goal of providing the highest level of resource value and function for the regional system. Endangered faunal species habitat and populations documented on-site shall be preserved on-site. Threatened faunal species and populations and species of special concern documented on-site, as well as critically imperiled, imperiled and rare plants shall be preserved on-site unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

3.1.9 Degradation or destruction of Natural Resources of Regional Significance, including listed species and their habitats will occur as a result of a proposed project only if:

a) the activity is necessary to prevent or eliminate a public hazard, and
b) the activity is in the public interest and no other alternative exists, and
c) the activity does not destroy significant natural habitat, or identified natural resource values, and
d) the activity does not destroy habitat for threatened or endangered species, and
e) the activity does not negatively impact listed species that have been documented to use or rely upon the site.

3.1.10 Proposed projects shall include buffer zones between development and existing Natural Resources of Regional Significance and other suitable natural resources. The buffer zones shall provide natural habitat values and functions that compliment Natural Resources of Regional Significance values so that the natural system values of the site are not negatively impacted by adjacent uses. The buffer zones shall be a minimum of 25 feet in width. Alternative widths may be proposed if it is demonstrated that the alternative furthers the viability of the Natural Resource of Regional Significance, effectively separating the development impacts from the natural resource or contributing to reduced fragmentation of identified Natural Resources of Regional Significance.

Strategic Regional Goal

3.4 Improve the protection of upland habitat areas and maximize the interrelationships between the wetland and upland components of the natural system.

Regional Policies

3.4.4 Require the use of ecological studies and site and species specific surveys in projects that may impact natural habitat areas to ensure that rare and state and federally listed plants and wildlife are identified with respect to temporal and spatial distribution.

3.4.5 Identify and protect the habitats of rare and state and federally listed species. For those rare and threatened species that have been scientifically demonstrated by past or site specific studies to be relocated successfully, without resulting in harm to the relocated or receiving populations, and where *in-situ* preservation is neither possible nor desirable from an ecological perspective, identify suitable receptor sites, guaranteed to be preserved and managed in perpetuity for the protection of the relocated species that will be utilized for the relocation of such rare or listed plants and animals made necessary by unavoidable project impacts. Consistent use of the site by endangered species, or documented endangered species habitat on-site shall be preserved on-site.

3.4.8 Remove invasive exotics from all Natural Resources of Regional Significance and associated buffer areas. Require the continued regular and periodic maintenance of areas that have had invasive exotics removed.

3.4.9 Required maintenance shall insure that re-establishment of the invasive exotic does not occur.

Strategic Regional Goal

3.8 Enhance and preserve natural system values of South Florida's shorelines, estuaries, benthic communities, fisheries, and associated habitats, including but not limited to, Florida Bay, Biscayne Bay and the coral reef tract.

Regional Policies

3.8.1 Enhance and preserve natural shoreline characteristics through requirements resulting from the review of proposed projects and in the implementation of ICE, including but not limited to, mangroves, beaches and dunes through prohibition of structural shoreline stabilization methods except to protect existing navigation channels, maintain reasonable riparian access, or allow an activity in the public interest as determined by applicable state and federal permitting criteria.

3.8.2 Enhance and preserve benthic communities, including but not limited to seagrass and shellfish beds, and coral habitats, by allowing only that dredge and fill activity, artificial shading of habitat areas, or destruction from boats that is the least amount practicable, and by encouraging permanent mooring facilities. Dredge and fill activities may occur on submerged lands in the Florida Keys only as permitted by the Monroe County Land Development Regulations. It must be demonstrated pursuant to the review of the proposed project features that the activities included in the proposed project do not cause permanent, adverse natural system impacts.

3.8.3 As a result of proposed project reviews, include conditions that result in a project that enhances and preserves marine and estuarine water quality by:

a) improving the timing and quality of freshwater inflows;
b) reducing turbidity, nutrient loading and bacterial loading from wastewater facilities and vessels;
c) reducing the number of improperly maintained stormwater systems; and
d) requiring port facilities and marinas to implement hazardous materials spill plans.

3.8.4 Enhance and preserve commercial and sports fisheries through monitoring, research, best management practices for fish harvesting and protection of nursery habitat and include the resulting information in educational programs throughout the region. Identified nursery habitat shall be protected through the inclusion of suitable habitat protective features including, but not limited to:

a) avoidance of project impacts within habitat area;
b) replacement of habitat area impacted by proposed project; or
c) improvement of remaining habitat area within remainder of proposed project area.

3.8.5 Enhance and preserve habitat for endangered and threatened marine species by the preservation of identified endangered species habitat and populations. For threatened species or species of critical concern, on-site preservation will be required unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

Thank you for the opportunity to comment. We would appreciate being kept informed on the progress of this project. Please do not hesitate to call if you have any questions or comments.

Sincerely,

Eric Silva
Senior Planner

ES/cp

cc: Col. James G. May, Department of the Army
Jean Evoy, Miami-Dade County DERM
Ana Gelabert-Sanchez, City of Miami

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive North
St. Petersburg, Florida 33702

February 23, 2001

James C. Duck, Chief
Planning Division, Environmental Branch
Department of the Army, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

The National Marine Fisheries Service (NMFS) has reviewed your letter dated January 29, 2001, requesting comments regarding the Shoreline Stabilization Project at Virginia Key Beach Park on the Atlantic Ocean, Dade County, Florida. The NMFS, by letter dated September 20, 2000, provided previous comments regarding an Expedited Reconnaissance Study for this project.

According to the study description provided, alternatives being considered for shore protection at the site include: constructing rock groins perpendicular to shore, removing and replacing existing timber groins, and/or placing beach fill along the shoreline. Although the study description did not include information regarding aquatic resources and potential adverse impacts to them, your letter indicates that an Environmental Assessment (EA) will be prepared for the proposed action. Based upon an interagency site inspection, as well as a preliminary assessment of the shoreward edge of seagrasses conducted by Dade County Department of Environmental Resources Management (DERM), several NMFS trust resources exist within the area of the study and may be impacted by the proposed project.

The proposed project is located in an area identified as Essential Fish Habitat (EFH) by the South Atlantic Fishery Management Council (SAFMC). Categories of EFH that occur, or may occur, within the project vicinity include marine water column, intertidal flats, seagrass, algae, and live/hard bottoms. Some of the managed species associated with these categories of EFH include postlarval, juvenile, and adult gray, mutton, lane and schoolmaster snappers, and white grunt. Seagrass habitat has been identified as EFH for postlarvae/juvenile red drum and brown and pink shrimp. Seagrass and algae communities have also been identified as EFH for larval spiny lobster. Hard bottom and seagrass habitats have been identified as EFH for juvenile and adult mutton snapper. Detailed information on shrimp, red drum, snapper/grouper complex (containing ten families and 73 species), spiny lobster, and other Federally managed fisheries and their EFH is provided in the 1998 amendment of the Fishery Management Plans (FMP) for the South Atlantic region prepared by the SAFMC. The 1998 generic amendment was prepared as required by the Magnuson-Stevens Fishery Conservation and Management Act (P.L. 94-265). The NMFS has developed an applicable FMP for highly migratory species that utilize the marine water column and seagrass beds in this area, including nurse, bonnethead, lemon, black tip, and bull sharks. In addition, seagrass and hard bottom habitats have also been designated as Habitat Areas of Particular Concern (HAPC) by the SAFMC for shrimp, snapper/grouper complex, red drum, and spiny lobster. HAPCs are subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area.

In addition to EFH for federally managed species, several of these habitats provide nursery, foraging, and refuge habitat for other commercially and recreationally important fish and shellfish. Species such as blue crab, snook, striped mullet, spotted seatrout, tarpon, and permit are among the many species that utilize these habitats. For example, seagrass habitat produces and exports detritus (decaying organic material) which is an essential element of the marine and estuarine food webs. Cumulatively, adverse impacts to these valuable marine habitats result in a reduction of overall fisheries productivity within the south Florida ecosystem.

During an interagency site inspection on January 17, 2001, seagrasses were present in the area where the placement of beach sand is proposed. A preliminary assessment of the shoreward edge of seagrass beds conducted by DERM on January 29, 2001, supported these observations. According to our discussions with Army Corps of Engineers staff regarding this proposed project, an alternative being considered for the project involves placement of sand on the beach above the mean high water line between monument R-85 and the southwest end of the project. However, placement of sand is also expected to occur over open water in the area northeast of monument R-85 and would appear to impact considerable seagrass.

The replacement of 27 timber groins and the construction of a breakwater within shallow marine habitats along the shoreline may cause direct impacts to seagrass beds and nearshore hard bottom habitats by direct burial and/or siltation. Seagrass beds may also be impacted during the removal of the existing timber groins and indirectly impacted by erosion or increased wave energy due to alteration in the hydrology from the structures or due to changes in the beach profile.

In view of the potential adverse effects of this project to EFH, HAPC and NOAA trust resources, the NMFS recommends that an EFH Assessment should be included as part of the EA, or as a separate document, and should include the following information:

1. A benthic survey should be conducted in the nearshore areas of the project. The survey should include species composition and abundance estimate for seagrass and hard bottom habitats within the area. The assessment should include an estimate of impacts to all marine resources from the proposed activity.

2. Mitigative measures to further avoid and minimize impacts to seagrass and other benthic resources due to the proposed action should be included. Alternatives to consider should include reducing the number of timber groins to be removed and replaced and avoiding the placement of sand in open water areas containing seagrass and/or hard bottom habitats.

3. A plan to fully compensate for unavoidable adverse impacts to seagrass, hard bottom, and other sensitive nearshore habitats should be developed and included in the document.

After our review of the EA and the EFH Assessment for the proposed activity, the NMFS will be able to more thoroughly assess the potential adverse impacts to EFH and associated marine resources. Based upon our review of the EA and any other NEPA documents, we may provide EFH Conservation Recommendations, as appropriate.

We appreciate the opportunity to provide these comments. If we can be of further assistance, please advise. Related comments, questions or correspondence should be directed to Michael R. Johnson in Miami. He may be contacted at 305-595-8352.

Sincerely,

W. Mark Thompson for
Andreas Mager, Jr.
Assistant Regional Administrator
Habitat Conservation Division

cc:
EPA, WPB
DEP, WPB
SAFMC, CHAS
FFWCC, TALL
FWS, VERO
NMFS, SEFSC-Goodyear
F/SER3
F/SER4
F/SER43-Johnson

Mailed out
2-12-01

Planning Division
Environmental Branch

FEB 12 2001

Mr. James J. Slack
U.S. Fish and Wildlife Service
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

Dear Mr. Slack:

This is in reference to the Section 111 Shoreline Stabilization Study being conducted at Virginia Key, Dade County, Florida.

Enclosed is a Biological Assessment pursuant to Section 7(a) of the Endangered Species Act. The U.S. Army Corps of Engineers has determined that the proposed action would not affect the West Indian manatee or the American crocodile, but may affect sea turtles. Therefore, we are requesting formal consultation with the U.S. Fish and Wildlife Service to address potential impacts the proposed project may have on sea turtles.

Please provide your Biological Opinion as specified in Section 7(b)(1) of the Act. If you have any questions or need further information, please contact Mr. Mike Dupes of my staff at 904-232-1689 or e-mail: michael.dupes@saj02.usace.army.mil.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosure

bcc(w/o encl.):
CESAJ-DP-I (Tefts)
CESAJ-PD-PN (White)

ENDANGERED SPECIES ACT
BIOLOGICAL ASSESSMENT
SECTION 111 SHORELINE STABILIZATION
VIRGINIA KEY, DADE COUNTY, FLORIDA

1. **Project Purpose and Authority.** A number of problems are being experienced at Virginia Key, which are attributable to the Federal navigation project at Miami Harbor. Construction activities at Miami Harbor have caused a decrease in the amount of sediment transported to the beaches on the southern end of Virginia Key. In addition wind generated waves and swells, tides and currents, and hurricanes and storms also contribute to the deterioration of the shoreline at Virginia Key. A Section 905(b) preliminary assessment was conducted in response to a letter dated July 25, 2000 from U.S. House of Representatives' Carrie P. Meek. The 905(b) assessment indicated that further detailed study was warranted to determine if mitigative measures were appropriate at Virginia Key due to negative impacts from previous improvements of the Federal navigation project at Miami Harbor. The feasibility study is being conducted under the Corps' continuing authority provided by Section 111 of the River and Harbor Act of 1968, as amended.

2. **Location.** The proposed project area is located within the boundaries of Virginia Key Beach Park on Virginia Key in Dade County, Florida. Virginia Key is a barrier island located between Biscayne Bay and the Atlantic Ocean south of Miami Beach and north of Key Biscayne. Refer to figure 1.

3. **Proposed Action.** In addition to the no-action plan, alternatives considered for stabilizing the shoreline at Virginia Key Beach include removing the existing timber groins and constructing rock groins perpendicular to the shoreline, removing and replacing the existing timber groins and constructing two new timber groins, and placing beach fill along the eroding shoreline. Any fill material placed on the beach will come from an upland sand source and will not be dredged from an offshore borrow area.

4. **References.** Several Biological Assessments and Biological Opinions have been prepared for previous shore protection projects in Dade County. These documents are listed below and are incorporated into this Biological Assessment by reference.

Biological Assessments Prepared by the U.S. Army Corps of Engineers (Corps):

Dade County Shore Protection Project, Sunny Isles and Miami Beach Segments – April 23, 1993.

Dade County Shore Protection Project, Surfside and South Miami Beach Segments – December 21, 1993.

Coast of Florida Erosion and Storm Effects Study, Region III – October 5, 1995.

amended on October 4, 2000.

8. Effect Assessment: Most of the construction activity will occur on land or in the immediate vicinity of the beach, within the project area, in shallow water. It is not likely that manatees will come into the shallow waters within or near the construction site. In addition precautions to protect the manatee, as described in the previous section, will be implemented therefore, the Corps has determined that proposed activities will have no effect on the manatee. Although the proposed project area is within the range of the American crocodile the eroded beach is not typical habitat for them therefore, crocodiles are not expected to be encountered. In the unlikely event that a crocodile does enter the project area the precautions described to protect the manatee would also protect the crocodile. The contractor would be advised that crocodiles could be encountered and that they are protected under the Endangered Species Act. The Corps has determined that the proposed activities will have no effect on the American crocodile. Because of the potential effects associated with nesting sea turtles, sea turtle nests, and hatchlings, the Corps has determined that the proposed action may affect sea turtles. No critical habitat has been identified that would be adversely affected by the proposed project.

FEB 0 8 2001

Planning Division
Environmental Branch

Dr. Katherine R. Wang
Acting Assistant Regional Administrator
for Protected Species
National Marine Fisheries Service
9721 Executive Center Drive, North
St. Petersburg, Florida 33702

Dear Dr. Wang:

This is in reference to the Section 111 Shoreline Stabilization Study at Virginia Key Beach, Dade County, Florida. For a description of the proposed action, please refer to the enclosed scoping letter dated January 29, 2001.

In addition to the no-action plan, alternatives considered for stabilizing the shoreline at Virginia Key Beach include removing the existing timber groins and constructing rock groins perpendicular to the shoreline, removing and replacing the existing timber groins and constructing two new timber groins, and placing beach fill along the eroding shoreline. Any fill material placed on the beach will come from an upland sand source and will not be dredged from an offshore borrow area. The U.S. Army Corps of Engineers has determined that none of the proposed alternatives would affect any listed threatened or endangered sea turtles, fishes, or marine mammals under the jurisdiction of the National Marine Fisheries Service. Your concurrence on this determination is requested.

Although the study area is outside the known southern range of Johnson's seagrass, *Halophila johnsonii*, we have learned in a discussion with Ms. Layne Bolen of your staff that it has been found just north of Virginia Key in Norris Cut. Because Norris Cut is in close proximity to the proposed project area, we are requesting informal Section 7 consultation, at this time, for Johnson's seagrass. To confirm or rule-out the presence of Johnson's seagrass in the vicinity of the proposed project, we will conduct a seagrass survey during April or May 2001.

If you have any questions or need any additional information, please contact Mr. Mike Dupes at 904-232-1689 or e-mail: michael.dupes@saj02.usace.army.mil.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosure

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

Planning Division
Environmental Branch

JAN 29 2001

TO WHO IT MAY CONCERN:

The Jacksonville District, U.S. Army Corps of Engineers, is conducting a study to evaluate alternatives for shoreline stabilization at Virginia Key Beach Park in Dade County, Florida. Please refer to the enclosed project information. An Environmental Assessment will be prepared to address environmental impacts of the proposed action.

We welcome your views, comments and information about natural and cultural resources, study objectives and important environmental features within the described study area, as well as any suggested improvements.

Letters of comment or inquiry should be directed within 30 days at the letterhead address to the attention of Planning Division, Environmental Branch.

Sincerely,

James C. Duck

James C. Duck
Chief, Planning Division

Enclosure

SECTION 111
SHORELINE STABILIZATION PROJECT
VIRGINIA KEY, DADE COUNTY, FLORIDA

1) Location. The study area is located within the boundaries of Virginia Key Beach Park on Virginia Key in Dade County Florida. Virginia Key is a barrier island located between Biscayne Bay and the Atlantic Ocean south of Miami Beach and north of Key Biscayne. Virginia Key is located in close proximity just south of Miami Harbor (refer to Figure 1). Rickenbacker Causeway provides access to the island from the mainland.

2) Feasibility Study Authority. A Section 905(b) preliminary assessment was conducted in response to a letter dated July 25, 2000 from U.S. House of Representatives' Carrie P. Meek. The 905(b) assessment indicated that further detailed study was warranted to determine if mitigative measures were appropriate at Virginia Key due to negative impacts from previous improvements of the Federal navigation project at Miami Harbor. This feasibility study is being conducted under the Corps' continuing authority provided by Section 111 of the River and Harbor Act of 1968, as amended. Section 111 reads as follows:

"The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate, study, and construct projects for the prevention or mitigation of shore damage attributable to Federal navigation works. The cost of implementing measures under this authority would be shared by non-Federal interests in the same proportion as the costs for the project causing the damage. The cost of operating and maintaining such projects shall be borne entirely by the non-Federal interests. No such project shall be constructed without specific authorization by Congress if the estimated first cost exceeds $5,000,000."

3) Feasibility Study Purpose. The purpose of the study is to determine the feasibility and Federal interest in modifications to Virginia Key as a result of the Miami Harbor Federal navigation project in order to stabilize the eroding shoreline at Virginia Key Beach Park.

4) Alternatives Considered. Several potential alternatives for stabilizing the shoreline are being considered. These alternatives include constructing rock groins perpendicular to the shoreline, removing and replacing the existing timber groins, and/or placing beach fill along the eroding shoreline.

VIRGINIA KEY BEACH PARK

SECTION 111 SHORELINE STABILIZATION PROJECT

FIGURE 1

MR RICHARD HARVEY
EPA - SOUTH FLORIDA OFFICE
400 NORTH CONGRESS AV SUITE 120
WEST PALM BEACH FL 33401

MS DONNA WIETING
US DEPARTMENT OF COMMERCE
HCHB SP ROOM 6117
14TH & CONSTITUTION AV NW
WASHINGTON DC 20230
(5 CYS)

COMMANDER
7TH COAST GUARD DISTRICT
BRICKELL PLAZA FED BLDG
909 SE 1ST AVENUE
MIAMI FL 33131-3050

MR HEINZ MUELLER
US ENVIR PROTECTION AGENCY
ENVIRONMENTAL POLICY SECTION
61 FORSYTH STREET
ATLANTA GA 30303-3104
(5 CYS)

HOUSING AND URBAN DEVELOPMENT
REGIONAL ENVIRONMENTAL OFFICER
75 SRING STREET SW ROOM 600-C
ATLANTA GA 30303-3309
(2 CYS)

MR MIKE JOHNSON
NATIONAL MARINE FISHERIES SERVIC
11420 NORTH KENDALL DR SUITE 103
MIAMI FL 33176

MR MARK THOMPSON
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3500 DELWOOD BEACH ROAD
PANAMA CITY FL 32408-7403

NATIONAL MARINE FISHERIES SERVICE
CHIEF PROTECTED SPECIES BRANCH
9721 EXECUTIVE CENTER DR NORTH
ST PETERSBURG FL 33702

DIRECTOR
NATIONAL MARINE FISHERIES SERVIC
SOUTHEAST FISHERIES SCIENCE CEN
75 VIRGINIA BEACH DRIVE
MIAMI FL 33149

MS WENDY TEAS
NATIONAL MARINE FISHERIES SERVICE
S E FISHERIES SCIENCE CENTER
75 VIRGINIA BEACH DRIVE
MIAMI FL 33149

REGIONAL DIRECTOR
NATIONAL MARINE FISHERIES SERVICE
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ST PETERSBURG FL 33702

REGIONAL DIRECTOR
FEMA INSURANCE & MITIGATION DIV
3003 CHAMBLEE-TUCKER ROAD
ATLANTA GA 30341

REGIONAL DIRECTOR
US FISH AND WILDLIFE SERVICE
1875 CENTURY BOULEVARD
ATLANTA GA 30345

SOUTHERN REGION FORESTER
US FOREST SERVICE - USDA
1720 PEACHTREE ROAD NW
ATLANTA GA 30309-2405

FIELD SUPERVISOR
US FISH AND WILDLIFE SERVICE
PO BOX 2676
VERO BEACH FL 32961-2676

US DEPARTMENT OF AGRICULTURE
NATURAL RES CONSER SERVICE
PO BOX 141510
GAINESVILLE FL 32614-1510

DIVISION OF STATE LANDS
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FLORIDA DEPT OF ENVIR PROTECTION
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FLORIDA DEPT OF ENVIR PROTECTION
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FLORIDA DEPT OF ENVIR PROTECTION
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PORT ST LUCIE FL 34952-7551

FLORIDA DEPT OF ENVIR PROTECTION
SOUTH FLORIDA DISTRICT
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FL FISH & WILDLIFE CONSERV COMM
255 154TH AVENUE
VERO BEACH FL 32968-9041

EXECUTIVE DIRECTOR
SOUTH FLORIDA WATER MGMT DIST
3301 GUN CLUB ROAD
WEST PALM BEACH FL 33416

SOUTH FLORIDA REG PLNG COUNCIL
3440 HOLLYWOOD BLVD SUITE 140
HOLLYWOOD FL 33021

FLORIDA STATE CLEARINGHOUSE
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2555 SHUMARD OAK BLVD
TALLAHASSEE FL 32399-2100
(16 CYS)

MR BRADLEY J HARTMAN
FL FISH & WILDLIFE CONSERV COMM
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620 SOUTH MERIDIAN STREET
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CITY MANAGER
CITY OF SOUTH MIAMI
SUNSET DRIVE
SOUTH MIAMI FL 33143

CITY MANAGER
CITY OF MIAMI BEACH
1700 CONVENTION CENTER DRIVE
MIAMI FL 33139

DIRECTOR
MIAMI BEACH PUBLIC WORKS DEPT
1700 CONVENTION CENTER DRIVE
MIAMI BEACH FL 33139

[illegible]
1/29/01

MAYOR
CITY OF MIAMI BEACH
1700 CONVENTION CENTER DRIVE
MI BEACH FL 33139

MAYOR
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N MIAMI BEACH FL 33162

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ONE GOLDEN BEACH DRIVE
GOLDEN BEACH FL 33160

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ONE GOLDEN BEACH DRIVE
GOLDEN BEACH FL 33160

YOR
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TOWN OF SURFSIDE
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PROFESSOR JOHN GIFFORD
RASMAS - UNIVERSITY OF MIAMI
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MIAMI FL 33149-1098

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

November 7, 2000

James C. Duck
Chief, Planning Division
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

Thank you for your letter and attachments to the Fish and Wildlife Service (Service) dated July 26, 2000, concerning technical assistance for a proposed shore protection and environmental restoration at Virginia Key Beach Park in Miami-Dade County, Florida. Virginia Key is a barrier island located south of Fisher Island and north of Key Biscayne, with the Atlantic Ocean to the east and Biscayne Bay to the west. This letter provides technical assistance on the protection and conservation of fish and wildlife resources in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*) and the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*).

PROJECT DESCRIPTION

The Army Corps of Engineers (Corps) is evaluating the feasibility of developing alternatives for improvements to the beach and to determine if further Federal action is recommended. You have also requested the participation of the Service in the development of the Project Study Plan, should the reconnaissance study conclude with a recommendation to continue into the feasibility study phase. The Corps is preparing a reconnaissance study for the shore protection and environmental restoration of Virginia Key Beach Park. The study is authorized under the authority for the Biscayne Bay Feasibility Study, which was authorized by Congress in 1982. The study was requested in a letter dated April 14, 2000, from U.S. Representative Carrie P. Meek, Congressional District 17.

Several potential alternatives for shore protection are being considered. These alternatives include constructing rock groins perpendicular to the shoreline, restoring some of the existing timber groins, removing the remaining timber groins, constructing a shore parallel breakwater, and/or placing beach sand along the eroding shoreline. Alternatives being considered for environmental restoration include removing exotic vegetation from wetlands and upland sites and restoring with native vegetation; restoring tidal flushing to the area as appropriate; creating beach dune habitat; and providing recreational features such as the pedestrian bridges, dune crossovers, boardwalks, interpretive signage and swimming buoys. Preliminary project scope includes restoration of the park's lagoon, wetlands, and indigenous plants. Non-native plants would be removed. The existing bathrooms and concessions at the park are also proposed for renovations by the City of Miami Public Works and Parks Department.

THREATENED AND ENDANGERED SPECIES

The Service has reviewed the information in your letter and attachments and examined information available to us on the presence of threatened and endangered species and trust resources in the vicinity of the proposed project. The coastal sandy beaches along Virginal Key provide habitat suitable for sea turtle nesting. Species most likely to nest in the project vicinity include the federally threatened loggerhead sea turtle (*Caretta caretta*), the endangered green sea turtle (*Chelonia mydas*), the endangered leatherback sea turtle (*Dermochelys coriacea*), and the endangered hawksbill sea turtle (*Eretmochelys imbricata*). The Service recommends that the Corps evaluate the level of nesting activities at the beach, the timing of the proposed beach renourishment, the grain size and mineral compatibility of the proposed fill material, and possible turbidity impacts from the fill material. The placement of rock and timber groins may impact the ability of nesting turtles to access the beach and may also interfere with hatchlings traveling to the water following their emergence from nests. The amount of nearshore habitat that will be impacted also needs to be quantified and possible environmental impacts assessed. These factors must be addressed by the Corps to allow the Service's review of project impacts to listed sea turtles.

The marine and estuarine waters and adjacent seagrass beds provide foraging habitat for the federally endangered West Indian manatee (*Trichechus manatus*). The Service recommends that the Corps provide an evaluation of project impacts to the manatee from construction actions and project impacts to foraging habitat for this species.

The mangrove forest and lagoon on the northern end of Virginia Key provide suitable habitat for the endangered American crocodile (*Crocodylus acutus*). Crocodiles are known to be present in the project area and may be nesting along the edge of the mangrove wetlands. Crocodile/human encounters are a likely occurrence in the project area and the Service recommends that a crocodile management plan be developed that addresses this issue. Portions of the project area are occupied by crocodiles, but the occupied habitat is not part of the designated critical habitat for this species.

FISH AND WILDLIFE RESOURCES

Mangroves are rare and important estuarine resources in Miami-Dade County. One of the primary functions that these tree species provide is shoreline stabilization. In addition, mangroves provide an invaluable contribution to the biodiversity of the marine and estuarine community. The mangrove forests of South Florida are a vital component of the estuarine and marine environment, providing a major detrital base to organic food chains, significant habitat for arboreal, intertidal and subtidal organisms, nesting sites, cover and foraging grounds for birds, and habitat for some reptiles and mammals. The mangrove forest provides protected nursery areas for fishes, crustaceans, and shellfish that are important to both commercial and sport fisheries.

The value and central role of mangroves in the ecology of South Florida has been well established by numerous scientific investigations directed at primary productivity, food web interactions, listed species, and support of sport and commercial fisheries. Mangroves are important in recycling nutrients and the nutrient mass balance of the estuarine ecosystem. They are one of the highest primary and associated secondary biologically productive ecosystems in the world. Mangroves provide one of the basic food chain resources for arboreal life and nearshore marine life through their leaves, wood, roots, and detrital materials. This primary production forms a significant part of the base of the arboreal, estuarine, and marine food web. Mangroves have a significant ecological role as physical habitat and nursery grounds for a wide variety of marine/estuarine vertebrates and invertebrates. Many of these species have significant sport fishery and/or commercial fishery value. This tropical ecosystem is a habitat unique in the continental United States. They deserve special protection because of this uniqueness and because of the multiple ecological functions they provide. Mangroves have a significant ecological role as habitat for endangered and threatened species, and species of special concern. For several of these species, the habitat is critical and vital to their continued survival. Mangroves serve as storm buffers by functioning as wind breaks and through prop-root baffling of wave action. Mangrove roots stabilize shorelines and fine substrates, reducing turbidity, and enhancing water clarity. Mangroves improve water quality and clarity by filtering upland runoff and trapping waterborne sediments and debris. Unaltered mangroves contribute to the overall natural setting and visual aesthetics of Florida's estuarine waterbodies. Through a combination of the above functions, mangroves contribute significantly to the economy of the coastal counties of South Florida and the State of Florida.

The adjacent seagrass beds provide a unique aquatic resource to the South Florida environment. Seagrasses are a highly productive, faunally rich, and ecologically important habitat within the coastal lagoons and estuaries of South Florida. In terms of primary productivity, a seagrass bed can produce four to ten times the weight of organic matter as that produced by a cultivated corn field of the same size. Vast, extensive seagrass beds covering hundreds of kilometers may be composed of one to maybe four species. Yet, hundreds to thousands of species of flora and fauna may inhabit these beds, utilizing the food, substrate, and shelter provided by these submerged plants. Rapidly growing seagrass leaves provide food for trophically higher organisms via direct herbivory or from the detrital food web. The structure formed by these leaves offers shelter and protection. This combination of shelter and food availability results in seagrass beds being the richest nursery grounds in South Florida's shallow coastal waters. As such, many commercial and recreational fisheries (*e.g.*, clams, shrimp, lobster, fish) are associated with seagrass beds. Seagrasses have experienced declines in abundance and distribution due to water quality degradation and through the direct loss of habitat related to dredge and fill activities (*e.g.*, navigation channels, marinas) and boating impacts (*e.g.*, propeller scars and groundings). The degradation of water quality is largely the result of point source pollution (*e.g.*, wastewater discharge, agricultural runoff, excessive freshwater discharge), nonpoint source pollution (*e.g.*, stormwater runoff, leaching from septic tanks), and the alteration of adjacent watersheds. The subsequent decline in seagrasses has significantly reduced the fisheries resources in South Florida. Implementation of several protective and restorative measures has improved water quality and reduced the rate of habitat loss within South Florida's estuaries. Such measures include the regulation of dredge and fill activities, the elimination of wastewater discharge to surface waters, the treatment of stormwater runoff, and the rehabilitation of adjacent watersheds. Turbidity associated with the fill placement may also affect marine species that reside and forage in the adjacent seagrass beds.

The Service recommends that the Corps review and evaluate the proposed project's impacts to these resources and provide in the alternatives evaluation actions that may be implemented to reduce impacts to these resources.

Thank you for the opportunity to participate as a team member in the preparation of a Project Study Plan for the proposed activity. The Service would be pleased to provide additional assistance, as available resources allow, to assist the Corps in the Project Study Plan. If you have any questions, please contact Mr. Allen Webb at (561) 562-3909, extension 246.

Sincerely yours,

Rob Pace for

James J. Slack
Field Supervisor
South Florida Ecological Services Office

cc:
NMFS, Andreas Mager, St. Petersburg, FL
EPA,West Palm Beach, FL
FWC, Stephen R. Lau, Vero Beach, FL
FDEP, Keith J. Mille, Tallahassee, FL
Miami-Dade County DERM, Stephen Blair, Miami, FL

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE

Southeast Regional Office
9721 Executive Center Drive North
St. Petersburg, Florida 33702

September 20, 2000

James C. Duck, Chief
Planning Division, Environmental Branch
Department of the Army, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Duck:

The National Marine Fisheries Service (NMFS) has reviewed your letter dated July 20, 2000, requesting comments regarding the Expedited Reconnaissance Study for shore protection and environmental restoration at Virginia Key Beach Park in Dade County, Florida.

According to the study description provided, alternatives being considered for shore protection at the site include: constructing rock groins perpendicular to shore, restoring some existing timber groins and removing the remaining timber groins, constructing a breakwater parallel to shore, and/or placing beach fill along the shoreline. Alternative being considered for environmental restoration include: exotic vegetation removal and restoring native vegetation, restoring tidal flushing to some areas, creating beach dune habitat, and providing various recreational features.

Although the study description did not include information regarding aquatic resources and potential adverse impacts to them, several NMFS trust resources may exist within the area of the study. Pursuant to the Magnuson-Stevens Fishery Conservation and Management Act, the South Atlantic Fishery Management Council (SAFMC) has identified Essential Fish Habitat (EFH) that may exist in the project area for species they manage including shrimp, the snapper-grouper complex (containing ten families and 73 species), Spanish and king mackerel, red drum, coral, and coral reef communities, and spiny lobster. The NMFS has identified EFH for highly migratory species that include billfishes and species of sharks that inhabit this area, such as nurse, blacktip, sandbar, lemon, and bull sharks. Various life stages of some managed species that may be found in the project area include larvae, postlarvae, juvenile and adult stages of red, gray, lane, schoolmaster, mutton and yellowtail snappers; scamp, speckled hind, red, yellowedge and gag groupers; Spanish and king mackerel; red drum; white grunt; and spiny lobster.

Categories of EFH that may be adversely impacted include marine water column, live/hard bottoms, coral, coral reefs, and artificial/manmade reefs, seagrasses, estuarine scrub/shrub mangroves, and intertidal flats. The SAFMC has identified EFH Habitat Areas of Particular Concern (HAPC) which may occur within the project area. HAPCs are subsets of EFH that are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Offshore areas of high habitat value or vertical relief, and habitats used for migration, spawning, and rearing of fish and shellfish have been included within HAPC. Specifically, categories of HAPC that may exist within the vicinity of the proposed project include hermatypic coral habitat and reefs, hard bottom habitats, and submerged aquatic vegetation. In addition, Biscayne National Park and Biscayne Bay are adjacent to the project location and are two geographically defined HAPC's (Biscayne Bay is also designated as an Outstanding Florida Water by the Florida Fish and Wildlife Conservation Commission).

In addition to EFH for Federally managed species, hard bottom, coral, seagrass; mangrove, and shallow nearshore habitats provide nursery, foraging, and refuge habitat for other commercially and recreationally important fish and shellfish. Species such as blue crab, flounder, spotted seatrout, pompano, snook, striped mullet, tarpon, and a variety reef fish and tropical fish are among the many species that utilize these habitats.

The potential sources of sand for the beach fill alternative were not discussed. Dredging sand from offshore borrow areas have been known to cause mechanical, siltation, and turbidity induced impacts to coral reefs and hard bottom habitats. Placement of sand along the shoreline and into nearshore waters may also impact corals, hard bottom, and seagrass habitat in similar manners.

Siltation can be detrimental to the growth and survival of reefs and the majority of associated species, especially filter-feeding organisms such as hard corals, sponges, and soft corals (Hay and Sutherland 1988). Other organisms such as algae, crustaceans, and fishes also can be adversely affected (Marszalek 1981; Goldberg 1989; Nelson 1989). Turbidity impacts are chronic perturbations that cause long-term reductions in primary and secondary productivity of reef and hard bottom communities by reducing water clarity and light penetration. Elevated turbidity levels near hard bottom and coral reef habitat is particularly detrimental to photosynthetic organisms such corals and algae (Dodge and Vaisnys 1977; Bak 1978). Because many organisms associated with nearshore hard bottom habitats are sessile and have no ability to burrow up through the sediment, the survivability of these communities after renourishment is minimal (Dodge and Vaisnys 1977; Marzalek 1981). The loss of primary production within the area of the fill placement eliminates an essential foraging resource for juvenile fish, turtles, and invertebrates.

At least eighty-six taxa of fish have been quantified among nearshore hard bottom habitats along southeast mainland Florida; including at least 34 species of juvenile reef fish which may utilize these habitats as nursery areas (Lindeman and Snyder 1999). Gilmore and Herrema (1981) recorded 107 species of fish from the littoral and sublittoral surf zone reefs of central-east Florida. Green, hawksbill, leatherback, and loggerhead turtles are known to nest and forage in Dade County and are protected by the NMFS and U.S. Fish and Wildlife Service under the Endangered Species Act of 1973. Between 10 and 16 nests per kilometer were reported annually for loggerhead turtles on Virginia Key Beach, and one endangered hawsbill turtle nest has been recorded (Florida Marine Research Institute 2000). Several studies have determined that nearshore hard bottom habitats along the southeast Florida coast are important as nursery habitat for juvenile green turtles and loggerheads (Guseman and Ehrhart 1990; Wershoven 1992). These studies have concluded that juvenile and adult turtles feed upon the large biomass of macroalgae available on these nearshore hard bottom habitats.

The placement of beach fill along the existing shoreline should only be considered after determination that nearshore seagrasses, corals, and hard bottom habitats will not be adversely affected by the action. Physical characteristics of fill material should match that of existing beach sand to minimize turbidity and provide appropriate turtle nesting habitat characteristics.

The construction of groins and a breakwater within shallow marine habitats along the shoreline may cause direct impacts to seagrass beds and nearshore hard bottom habitats by burial. Seagrass beds may also be indirectly impacted by erosion or increased wave energy due to alteration in the hydrology from the structures. The proposed groins and breakwater may adversely affect sea turtles by reducing or inhibiting the ability of adult female turtles to access the beach during nesting season, of hatchlings during emigration from the beach, and juveniles/adults for foraging in nearshore hard bottom habitats. Groins and breakers may also cause erosion of nesting beach habitat downdrift of these structures.

The NMFS supports the alternatives for environmental restoration of the area including the removal of exotic vegetation, restoration of native vegetation, restoration of natural tidal flushing, creation/enhancement of beach dune habitat, and construction of low-impact recreational features.

We appreciate the opportunity to provide these comments. If we can be of further assistance, please advise. Related comments, questions or correspondence should be directed to Michael R. Johnson in Miami. He may be contacted at 305-595-8352.

Sincerely,

W. Mark Thompson/for

Andreas Mager, Jr.
Assistant Regional Administrator
Habitat Conservation Division

cc:
EPA, WPB
DEP, WPB
SAFMC, CHAS
FFWCC, TALL
FWS, VERO
NMFS, SEFSC-Goodyear
F/SER3
F/SER4

Literature Cited

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Marszalek, D.S. 1981. Impacts of dredging on a subtropical reef community, southeast Florida, U.S.A. Proc. 4th Intl. Coral Reef Symposium, Manila, Vol. 1:147-153.

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Wershoven, J.L. 1992. Juvenile green turtles in their nearshore habitat of Broward County, Florida: a five-year review. *In* Proc. 11th Annual Workshop on Sea Turtle Biology and Conservation. NOAA Tech. Memo., NMFS-SEFC-302. p. 185-187.

JEB BUSH
Governor

STEVEN M. SEIBERT
Secretary

September 11, 2000

Mr. James C. Duck
Department of the Army
Jacksonville District Corps of Engineers
Post Office Box 4970
Jacksonville, Florida 32232-0019

RE: Department of the Army - District Corps of Engineers - Section 905(b) Expedited Reconnaissance Study - Shore Protection and Environmental Restoration - Virginia Key Beach Park - Miami-Dade County, Florida
SAI: FL200007310528C

Dear Mr. Duck:

The Florida State Clearinghouse, pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 95-359, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, has coordinated a review of the above-referenced project.

The Department of Environmental Protection (DEP) offers a number of comments and recommendations regarding the proposed project. DEP notes that the placement of riprap at or above the mean high water line would require an Environmental Resource Permit regulatory permit and a Consent of Use for sovereignty, submerged lands. Additional permits may be required depending on the alternatives selected. DEP looks forward to working with the Corps and the community to develop a viable project. Please refer to the enclosed DEP comments.

The South Florida Water Management District (SFWMD) notes that, under the operating agreement between the Department of Environmental Protection (DEP) and the SFWMD, this project will be reviewed by DEP. Please refer to the enclosed SFWMD comments.

Based on the information contained in the above-referenced project proposal and the enclosed comments provided by our reviewing agencies, the state has determined that the above-referenced project is consistent with the Florida Coastal Management Program.

Mr. James C. Duck
September 11, 2000
Page Two

In addition, the South Florida Regional Planning Council (SFRPC) has identified the policies and goals of its Strategic Regional Policy Plan which may apply to the proposed activity. The comments provided by the SFRPC are enclosed for your review and consideration.

If you have any questions regarding this letter, please contact Ms. Cherie Trainor, Clearinghouse Coordinator, at (850) 414-5495.

Sincerely,

Ralph Cantral, Executive Director
Florida Coastal Management Program

RC/cc

Enclosures

cc: Robert Hall, Department of Environmental Protection
Jim Golden, South Florida Water Management District
Eric Silva, South Florida Regional Planning Council

Department of Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Jeb Bush
Governor

David B. Struhs
Secretary

August 31, 2000

RECEIVED
SEP 05 2000
State of Florida Clearinghouse

Ms. Cherie Trainor
Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100

Re: Department of the Army, District Corps of Engineers, Section 905(b) Expedited Reconnaissance Study, Shore Protection and Environmental Restoration, Virginia Key Beach Park, Miami-Dade County

SAI: FL20007310528C

Dear Ms. Trainor:

This Department has reviewed the above-described project proposal and based on the information provided, we submit the following comments and recommendations.

Comments:

Virginia Key Beach Park possesses a unique array of plant species within its beachfront dune, coastal strand, marine hardwood hammock and mangrove wetland communities. The Florida Natural Areas Inventory (FNAI) lists several rare plants found on the Key, including Biscayne prickly ash, the broad-leafed spider lily, the burrowing four-o'clock the necklace pod, and the sea lavender (see attached FNAI report dated August 10, 2000). Virginia Key Beach also provides important habitat for several species of shorebirds including the following threatened or endangered species: peregrine falcon, bald eagle, piping plover, and the roseate spoonbill. A gopher tortoise has also been observed at the site.

The study proposal lists potential shore protection and environmental restoration projects in conjunction with its site map. Additional details are needed on the alternatives being considered, in order to more accurately assess the potential benefits and impacts of this project. The beach has experienced significant erosion in this area, and since erosion has the potential to impact species whose dune habitat may be reduced or eliminated, a thorough evaluation of listed project alternatives would be desirable to include the following concerns:

1. Seagrass beds are plentiful in the study area and manatee observations are common in the nearby offshore waters of Virginia Key. Beach restoration efforts should address potential impacts to this resource.

2. Virginia Key Beach is a nesting area of the loggerhead sea turtle (caretta caretta). In 1994, the National Marine Fisheries Service documented 52 nests on the island. Shore protection efforts should consider compatibility with nesting sea turtles including the suitability of fill, if proposed.

3. A 1990 FNAI report indicated that most of the island is covered by a strand of Australian Pine (Casuarina equisetifolia). Any beach restoration should include removal of this exotic species, as its uprooting can contribute to accelerated beach erosion.

4. The proposed Restoration of tidal flow should be accompanied by an evaluation of alternatives for the disposal or placement of spoil material

5. Management requirements of the Biscayne Bay Aquatic Preserve are spelled out in Chapter 18-18, Florida Administrative Code. Special attention should be paid to Section 18-18.005, F.A.C., *General Management Criteria*, and Section 18-18.006, F.A.C., *Uses, Sales, Leases or Transfers of Interests in Lands or Materials Held by the Board*.

Recommendations:

In order to protect the shoreline from further erosion, staff recommends that the Corps explore either the restoration of existing timber groins, or the placement of riprap at or above the line of mean high water. It is felt that these alternatives would have the least impacts to wetland and submerged aquatic vegetation. The placement of riprap at or above the mean high water line would require an ERP regulatory permit and a Consent of Use for sovereignty, submerged lands. Other permits may be required depending on the alternatives selected. The department looks forward to working with the Corps and the community to develop a viable project.

Thank you for the opportunity of commenting on this proposal. If you have any questions regarding this letter please give me a call at (850) 487-2231.

Sincerely,

Robert W. Hall

Robert W. Hall
Office of Intergovernmental Programs

Attachment
cc: Anna Marie Hartman
David Mayer
Cheryl McKee
Jayne Bergstrom

COUNTY: Miami-Dade

DATE: 07/31/2000
COMMENTS DUE DATE: 08/30/2000
CLEARANCE DUE DATE: 09/11/2000
SAI#: FL20000731052

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State X Transportation	South Florida WMD	Environmental Policy/C & ED

RECEIVED
AUG 04 2000
State of Florida Clearinghouse

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

___ Federal Assistance to State or Local Government (15 CFR 930, Subpart F). Agencies are required to evaluate the consistency of the activity.

_X_ Direct Federal Activity (15 CFR 930, Subpart C). Federal Agencies are required to furnish a consistency determination for the State's concurrence or objection.

___ Outer Continental Shelf Exploration, Development or Production Activities (15 CFR 930, Subpart E). Operators are required to provide a consistency certification for state concurrence/objection.

___ Federal Licensing or Permitting Activity (15 CFR 930, Subpart D). Such projects will only be evaluated for consistency when there is not an analogous state license or permit.

Project Description:

Department of the Army - District Corps of Engineers - Section 905(b) Expedited Reconnaissance Study - Shore Protection and Environmental Restoration - Virginia Key Beach Park - Miami-Dade County, Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 922-5438 (SC 292-5438)
(850) 414-0479 (FAX)

EO. 12372/NEPA

- [x] No Comment
- [ ] Comments Attached
- [ ] Not Applicable

Federal Consistency

- [x] No Comment/Consistent
- [ ] Consistent/Comments Attached
- [ ] Inconsistent/Comments Attached
- [ ] Not Applicable

From:
Division/Bureau: FDOT
Reviewer: [signature]
Date: 8/3/00

AUG-04-2000 11:50 SFWMD-REG 561 682 6896 P.02/03

COUNTY: Miami-Dade

DATE: 07/31/2000
COMMENTS DUE DATE: 08/30/2000
CLEARANCE DUE DATE: 09/11/2000
SAI#: FL200007310528C

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State Transportation	X South Florida WMD	Environmental Policy/C & ED

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ERR - 4210

The attached document requires a Coastal Zone Management Act/Florida Coastal Management Program consistency evalutation and is categorized as one of the following:

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Project Description:

Department of the Army - District Corps of Engineers - Section 905(b) Expedited Reconnaissance Study - Shore Protection and Environmental Restoration - Virginia Key Beach Park - Miami-Dade County, Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 922-5438 (SC 292-5438)
(850) 414-0479 (FAX)

EO. 12372/NEPA

☐ No Comment
☐ Comments Attached
☐ Not Applicable

Federal Consistency

☐ No Comment/Consistent
☐ Consistent/Comments Attached
☐ Inconsistent/Comments Attached
☒ Not Applicable

UNDER THE OPERATING AGREEMENT BETWEEN DEP AND THE SFWMD, THIS PROJECT WILL BE REVIEWED BY DEP.

From:
Division/Bureau: ERR
Reviewer: [illegible]
Date: 8/4/00

COUNTY: Miami-Dade

DATE: 07/31/2000
COMMENTS DUE DATE: 08/30/2000
CLEARANCE DUE DATE: 09/11/2000
SAI#: FL20000731052

Message:

STATE AGENCIES	WATER MANAGEMENT DISTRICTS	OPB POLICY UNITS
Community Affairs Environmental Protection Fish & Wildlife Conserv. Comm State Transportation	South Florida WMD	X Environmental Policy/C & ED

RECEIVED
AUG 14 2000
State of Florida Clearinghouse

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Project Description:

Department of the Army - District Corps of Engineers - Section 905(b) Expedited Reconnaissance Study - Shore Protection and Environmental Restoration - Virginia Key Beach Park - Miami-Dade County, Florida.

To: Florida State Clearinghouse
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
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EO. 12372/NEPA

- ☐ ~~No Comment~~
- ☐ Comments Attached
- ☐ Not Applicable

Federal Consistency

- ☐ No Comment/Consistent
- ☐ Consistent/Comments Attached
- ☐ Inconsistent/Comments Attached
- ☐ Not Applicable

From:

Division/Bureau: Ex. O. of Pb. Env. Policy

Reviewer: M Massey

Date: 8/15/2000

FL200007310528C

South
Florida
Regional
Planning
Council

RECEIVED
AUG 17 2000
State of Florida Clearinghouse

August 15, 2000

Ms. Cherie Trainor
Florida State Clearinghouse
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100

RE: SFRPC #00-0759 - Response to a request for comments on the expedited reconnaissance study for the combined shore protection and environmental restoration at the Virginia Key Beach Park, U.S. Department of the Army, Miami-Dade County.

Dear Ms. Trainor:

We have reviewed the above-referenced project and have the following comments:

- Beaches and dune systems are identified as natural resources of regional significance in the *Strategic Regional Policy Plan for South Florida*. Council staff supports the implementation of beach renourishment projects for the purposes of providing storm protection for upland property, restoring dunes and maintaining eroding beaches. Staff supports the use of buffer zones to protect these important resources.

- The use of groins and other hard coastal protection structures may adversely impact benthic resources and deprive downdrift shorelines of sand. Sand movement and downdrift erosion should be monitored on a region wide basis to ensure the livelihood of wildlife habitats and the stability of renourished areas. All actions should be consistent with the goals and policies of the Miami-Dade County comprehensive plan.

- In addition, the permit application indicates that the project may impact sea turtles and essential fish habitat. Staff recommends that, if the proposed actions are implemented, 1) impacts to the natural systems be minimized to the greatest extent feasible and 2) the permit grantor determine the extent of sensitive marine life and vegetative communities in the vicinity of each project and require protection and or mitigation of disturbed habitat. These guidelines will assist in reducing the cumulative impacts to native plants and animals, wetlands and deep water habitat and fisheries that the goals and policies of the *Strategic Regional Policy Plan for South Florida* seek to protect.

- The goals and policies of the *Strategic Regional Policy Plan for South Florida*, in particular those indicated below, should be observed when making decisions regarding this project.

Strategic Regional Goal

3.1 Eliminate the inappropriate uses of land by improving the land use designations and utilize land acquisition where necessary so that the quality and connectedness of Natural Resources of Regional Significance and suitable high quality natural areas is improved.

Regional Policies

3440 Hollywood Boulevard, Suite 140, Hollywood, Florida 33021
Broward (954) 985-4416. Area Codes 305, 407 and 561 (800) 985-4416
SunCom 473-4416, FAX (954) 985-4417, SunCom FAX 473-4417
e-mail sfadmin@sfrpc.com

3.1.1 Natural Resources of Regional Significance and other suitable natural resources shall be preserved and protected. Mitigation for unavoidable impacts will be provided either on-site or in identified regional habitat mitigation areas with the goal of providing the highest level of resource value and function for the regional system. Endangered faunal species habitat and populations documented on-site shall be preserved on-site. Threatened faunal species and populations and species of special concern documented on-site, as well as critically imperiled, imperiled and rare plants shall be preserved on-site unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

3.1.9 Degradation or destruction of Natural Resources of Regional Significance, including listed species and their habitats will occur as a result of a proposed project only if:

a) the activity is necessary to prevent or eliminate a public hazard, and
b) the activity is in the public interest and no other alternative exists, and
c) the activity does not destroy significant natural habitat, or identified natural resource values, and
d) the activity does not destroy habitat for threatened or endangered species, and
e) the activity does not negatively impact listed species that have been documented to use or rely upon the site.

3.1.10 Proposed projects shall include buffer zones between development and existing Natural Resources of Regional Significance and other suitable natural resources. The buffer zones shall provide natural habitat values and functions that compliment Natural Resources of Regional Significance values so that the natural system values of the site are not negatively impacted by adjacent uses. The buffer zones shall be a minimum of 25 feet in width. Alternative widths may be proposed if it is demonstrated that the alternative furthers the viability of the Natural Resource of Regional Significance, effectively separating the development impacts from the natural resource or contributing to reduced fragmentation of identified Natural Resources of Regional Significance.

Strategic Regional Goal

3.4 Improve the protection of upland habitat areas and maximize the interrelationships between the wetland and upland components of the natural system.

Regional Policies

3.4.4 Require the use of ecological studies and site and species specific surveys in projects that may impact natural habitat areas to ensure that rare and state and federally listed plants and wildlife are identified with respect to temporal and spatial distribution.

3.4.5 Identify and protect the habitats of rare and state and federally listed species. For those rare and threatened species that have been scientifically demonstrated by past or site specific studies to be relocated successfully, without resulting in harm to the relocated or receiving populations, and where *in-situ* preservation is neither possible nor desirable from an ecological perspective, identify suitable receptor sites, guaranteed to be preserved and managed in perpetuity for the protection of the relocated species that will be utilized for the relocation of such rare or listed plants and animals made necessary by unavoidable project impacts. Consistent use of the site by endangered species, or documented endangered species habitat on-site shall be preserved on-site.

3.4.8 Remove invasive exotics from all Natural Resources of Regional Significance and associated buffer areas. Require the continued regular and periodic maintenance of areas that have had invasive exotics removed.

3.4.9 Required maintenance shall insure that re-establishment of the invasive exotic does not occur.

Strategic Regional Goal

3.8 Enhance and preserve natural system values of South Florida's shorelines, estuaries, benthic communities, fisheries, and associated habitats, including but not limited to, Florida Bay, Biscayne Bay and the coral reef tract.

Regional Policies

3.8.1 Enhance and preserve natural shoreline characteristics through requirements resulting from the review of proposed projects and in the implementation of ICE, including but not limited to, mangroves, beaches and dunes through prohibition of structural shoreline stabilization methods except to protect existing navigation channels, maintain reasonable riparian access, or allow an activity in the public interest as determined by applicable state and federal permitting criteria.

3.8.2 Enhance and preserve benthic communities, including but not limited to seagrass and shellfish beds, and coral habitats, by allowing only that dredge and fill activity, artificial shading of habitat areas, or destruction from boats that is the least amount practicable, and by encouraging permanent mooring facilities. Dredge and fill activities may occur on submerged lands in the Florida Keys only as permitted by the Monroe County Land Development Regulations. It must be demonstrated pursuant to the review of the proposed project features that the activities included in the proposed project do not cause permanent, adverse natural system impacts.

3.8.3 As a result of proposed project reviews, include conditions that result in a project that enhances and preserves marine and estuarine water quality by:

a) improving the timing and quality of freshwater inflows;
b) reducing turbidity, nutrient loading and bacterial loading from wastewater facilities and vessels;
c) reducing the number of improperly maintained stormwater systems; and
d) requiring port facilities and marinas to implement hazardous materials spill plans.

3.8.4 Enhance and preserve commercial and sports fisheries through monitoring, research, best management practices for fish harvesting and protection of nursery habitat and include the resulting information in educational programs throughout the region. Identified nursery habitat shall be protected through the inclusion of suitable habitat protective features including, but not limited to:

a) avoidance of project impacts within habitat area;
b) replacement of habitat area impacted by proposed project; or
c) improvement of remaining habitat area within remainder of proposed project area.

3.8.5 Enhance and preserve habitat for endangered and threatened marine species by the preservation of identified endangered species habitat and populations. For threatened species or species of critical concern, on-site preservation will be required unless it is demonstrated that off-site mitigation will not adversely impact the viability or number of individuals of the species.

Thank you for the opportunity to comment. We would appreciate being kept informed on the progress of this project. Please do not hesitate to call if you have any questions or comments.

Sincerely,

for

Eric Silva
Senior Planner

ES/cp

Telepho

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

JUL 24 2000

Planning Division
Environmental Branch

TO WHOM IT MAY CONCERN:

The Jacksonville District, U.S. Army Corps of Engineers, has initiated a Section 905(b) Expedited Reconnaissance Study for combined shore protection and environmental restoration at Virginia Key Beach Park in Dade County, Florida. The enclosed study description is provided for your information.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosure

Mr. Duck:

Any activities proposed should take into account potential presence of Johnson's seagrass, a federally-listed "threatened" species, at the site. If you have any questions please contact Ms. Layne Bolen of NMFS Protected Resources Division 850/243-2492 or layne.bolen@noaa.gov

Sincerely,
Eric G. Hawk
NMFS SE Region
ESA Section 7 Coordinator

RECEIVED
JUL 27 2000

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

JUL 24 2000

Planning Division
Environmental Branch

TO WHOM IT MAY CONCERN:

The Jacksonville District, U.S. Army Corps of Engineers, has initiated a Section 905(b) Expedited Reconnaissance Study for combined shore protection and environmental restoration at Virginia Key Beach Park in Dade County, Florida. The enclosed study description is provided for your information.

Sincerely,

James C. Duck
Chief, Planning Division

Enclosure

Section 905(b) Expedited Reconnaissance Study

Shore Protection and Environmental Restoration
Virginia Key Beach Park
Dade County, Florida

Study Description

1. Location. The study area is located within the boundaries of Virginia Key Beach Park on Virginia Key in Dade County, Florida. Virginia Key is a barrier island located south of Fisher and north of Key Biscayne with the Atlantic Ocean to the east and Biscayne Bay to the west (Refer to Figure 1).

2. Reconnaissance Study Authority. This study is authorized under the authority for the Biscayne Bay Feasibility Study, which was authorized by Congress in 1982. The study was requested in a letter dated April 14, 2000 from U.S. Representative Carrie P. Meek, Congressional District 17.

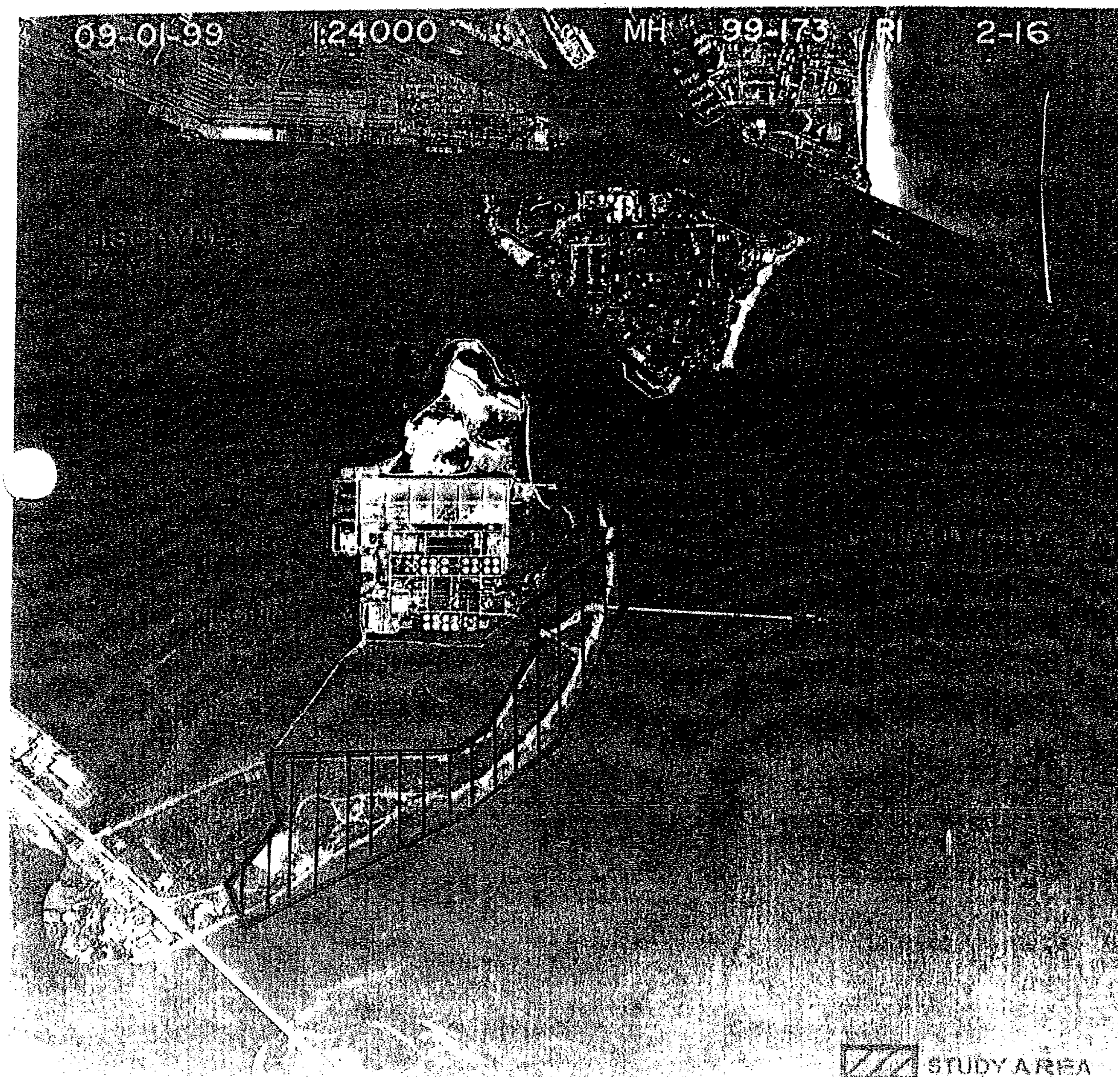
3. Improvements Considered. Several potential alternatives for shore protection are being considered. These alternatives include constructing rock groins perpendicular to the shoreline, restoring some of the existing timber groins and removing the remaining timber groins, constructing a shore parallel breakwater, and/or placing beach fill along the eroding shoreline. Alternatives being considered for environmental restoration include removing exotic vegetation from wetland and upland sites and restoring with native vegetation, restore tidal flushing to areas as appropriate, create beach dune habitat, and provide recreational features such as pedestrian bridges, dune crossovers, boardwalks, interpretive signage and swimming buoys.

4. Study Purpose. The purpose of the Reconnaissance Study is to determine if there is a Federal interest in providing shore protection and environmental restoration on Virginia Key, determine if there are feasible alternatives for shore protection and environmental restoration, and determine if further action is recommended.

Enclosure

VIRGINIA KEY BEACH PARK

RECONNAISSANCE STUDY



KEY BISCAYNE

FIGURE 1

MR RICHARD HAMMER
CONTINENTAL SHELF ASSOCIATES
759 PARKWAY STREET
JUPITER FL 33477

ENVIRONMENTAL SERVICES INC
8711 PERIMETER PARK BLVD SUITE 11
JACKSONVILLE FL 32216

MR JOHN SZELIGOWSKI
TAMS CONSULTANTS
655 3RD AVENUE
NEW YORK NY 10017

AIRMAN
RICAN LITTORAL SOCIETY
IRGINIA BEACH DRIVE
KEY BISCAYNE FL 33149

MR ALEXANDER STONE
AMERICAN LITTORAL SOCIETY (BHNI)
2809 BIRD AVENUE PMB 162
MIAMI FL 33133

MR DAVID GODFREY
CARIBBEAN CONSERVATION CORP
PO BOX 2866
GAINESVILLE FL 32602-2866

MR DONALD J DUERR
BIODIVERSITY ASSOCIATES
PO BOX 6032
LARAMIE WY 82070

MR DICK TOWNSEND
TROPICAL AUDUBON SOCIETY
7985 SW 124TH STREET
MIAM FL 33156

FLORIDA WILDLIFE FEDERATION
PO BOX 6870
TALLAHASSEE FL 32314-6870

ISAAK WALTON LEAGUE OF AMERICA
5314 BAY STATE ROAD
PALMETTO FL 33561-9712

MR JIM VON OISTE
REEFKEEPER INTERNATIONAL
2809 BIRD AVENUE PMB 162
MIAMI FL 33133

NATIONAL WILDLIFE FEDERATION
1330 WEST PEACHTREE STREET
SUITE 475
ATLANTA GA 30309

NATURE CONSERVANCY
FLORIDA CHAPTER
222 S WESTMONTE DR SUITE 300
ALTAMONTE SPRINGS FL 32714-4269

CONSERVATION CHAIRMAN
SIERRA CLUB
9829 SW 62 COURT
MIAMI FL 33156

CHAIRMAN
SIERRA CLUB
PO BOX 430741
MIAMI FL 33142-0741

MR JOHN FORTUIN
SIERRA CLUB MIAMI GROUP
BOX 398715
I BEACH FL 33239

MR DON CHINQUINA
TROPICAL AUDUBON SOCIETY
5530 SUNSET DRIVE
MIAMI FL 33143

REGIONAL DIRECTOR
THE WILDERNESS SOCIETY
900 17TH STREET NW
WASHINGTON 20006-2501

MR WALTER BRESSLOUR
CONCERNED CITIZENS NE DADE
COUNTY
201 178TH DRIVE #516
SUNNY ISLES

FRIENDS OF THE EVERGLADES
7800 RED ROAD STE 215K
MIAMI

MR RICHARD HARVEY
EPA - SOUTH FLORIDA OFFICE
400 NORTH CONGRESS AV SUITE 120
WEST PALM BEACH FL 33401

MS DONNA WIETING
US DEPARTMENT OF COMMERCE
HCHB SP ROOM 6117
14TH & CONSTITUTION AVENUE NW
WASHINGTON DC 20230
(5 CYS)

COMMANDER (OAN)
7TH COAST GUARD DISTRICT
909 SE 1ST AVENUE
BRICKNELL PLAZA FED BLDG
MIAMI FL 33131-3050

MR HEINZ MUELLER
US ENVIR PROTECTION AGENCY
ENVIRONMENTAL POLICY SECTION
61 FORSYTH STREET
ATLANTA GA 30303-3104
(5 CYS)

HOUSING AND URBAN DEVELOPMENT
REGIONAL ENVIRONMENTAL OFFICER
75 SPRING STREET SW ROOM 600-C
ATLANTA GA 30303-3309
(2 CYS)

MR MIKE JOHNSON
NATIONAL MARINE FISHERIES SERVICE
11420 NORTH KENDALL DR SUITE 103
MIAMI FL 33176

NATIONAL MARINE FISHERIES SERVICE
CHIEF PROTECTED SPECIES BRANCH
9721 EXECUTIVE CENTER DRIVE
ST PETERSBURG FL 33702

REGIONAL DIRECTOR
NATIONAL MARINE FISHERIES SERVICE
9721 EXECUTIVE CENTER DRIVE
ST PETERSBURG FL 33702

REGIONAL DIRECTOR
FEMA INSURANCE & MITIGATION DIV
3003 CHAMBLEE-TUCKER ROAD
ATLANTA GA 30341

REGIONAL DIRECTOR
US FISH AND WILDLIFE SERVICE
1875 CENTURY BOULEVARD
ATLANTA GA 30345

SOUTHERN REGION FORESTER
US FOREST SERVICE - USDA
1720 PEACHTREE ROAD NW
ATLANTA GA 30309-2405

FIELD SUPERVISOR
US FISH AND WILDLIFE SERVICE
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VERO BEACH FL 32961-2676

US DEPARTMENT OF AGRICULTURE
NATURAL RES CONSER SERVICE
PO BOX 141510
GAINESVILLE FL 32614-1510

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FLORIDA HOUSE OF REPRESENTATIVES
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MIAMI BEACH FL 33141-3038

HONORABLE SALLY A HEYMAN
FLORIDA HOUSE OF REPRESENTATIVES
17101 NE 19TH AVENUE SUITE 205
NORTH MIAMI BEACH FL 33162-3159

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FLORIDA HOUSE OF REPRESENTATIVE
201 WEST FLAGLER STREET
MIAMI 33130-1510

NORABLE GUSTAVO BARREIRO
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FLORIDA STATE SENATE
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CITY MANAGER
CITY OF SOUTH MIAMI
6130 SUNSET DRIVE
SOUTH MIAMI FL 33143

CITY MANAGER
CITY OF MIAMI BEACH
1700 CONVENTION CENTER DRIVE
MIAMI FL 33139

DIRECTOR
MIAMI BEACH PUBLIC WORKS DEPT
1700 CONVENTION CENTER DRIVE
MIAMI BEACH FL 33139

MAYOR
CITY OF MIAMI BEACH
1700 CONVENTION CENTER DRIVE
MIAMI BEACH FL 33139

MAYOR
CITY OF MIAMI SHORES
10050 NE 2ND AVENUE
MIAMI SHORES FL 33138

CITY MANAGER
CITY OF MIAMI
3500 PAN AMERICAN DRIVE
MIAMI FL 33133

MAYOR
CITY OF MIAMI
3500 PAN AMERICAN DRIVE
MIAMI FL 33133

CITY MANAGER
CITY OF NORTH MIAM IBEACH
17011 NE 19 AVENUE
NORTH MIAMI BEACH FL 33162

MAYOR
CITY OF NORTH MIAMI
776 NE 125 STREET
NORTH MIAMI FL 33161

METROPOLITAN DADE COUNTY
BOARD OF COUNTY COMMISSIONERS
111 NW 1ST STREET
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MR BRIAN FLYNN
DADE CO DEPT OF ENVIR RES MGMT
SW 2ND AVENUE SUITE 300
II FL 33130

MR STEVE BLAIR
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33 SW 2ND AVENUE SUITE 300
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MAYOR
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BAY HARBOR ISLAND FL 33154

TOWN MANAGER
TOWN OF GOLDEN BEACH
ONE GOLDEN BEACH DRIVE
GOLDEN BEACH FL 33160

MAYOR
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ONE GOLDEN BEACH DRIVE
GOLDEN BEACH FL 33160

MAYOR
TOWN OF SURFSIDE
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SURFSIDE FL 33154

TOWN MANAGER
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6130 SUNSET DRIVE
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KEY BISCAYNE

MAYOR
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MAYOR
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50 INDIAN CREEK ISLAND
INDIAN CREEK VILLAGE

MAYOR
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FT LAUDERDALE FL 33316

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3900 COMMONWEALTH BLVD MS 105
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SOUTH FLORIDA REG PLNG COUNCIL
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HOLLYWOOD FL 33021

FLORIDA STATE CLEARINGHOUSE
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TALLAHASSEE FL 32399-2100
(16 CYS)

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RASMAS - UNIVERSITY OF MIAMI
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MIAMI FL 33137

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US HOUSE OF REPRESENTATIVES
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[illegible]I FL 33173

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FT LAUDERDALE FL 33301

HONORABLE BOB GRAHAM
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MIAMI FLORIDA 33130

HONORABLE CONNIE MACK
UNITED STATES SENATOR
777 BRICKELL AVENUE SUITE 704
MIAMI FL 33131

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

31 JUL 2000

REPLY TO
ATTENTION OF:

Honorable Carrie P. Meek
U.S. House of Representatives
Washington, D. C. 20515

Dear Ms. Meek:

Reference your letter dated July 25, 2000, and our telephone conversation of July 28, 2000, regarding local interest in restoration of the historic beach area on Virginia Key, Florida, a coastal barrier island in Miami, Florida.

As you are aware, the United States Army Corps of Engineers, Jacksonville District, was already involved in a 905(b) preliminary assessment of shoreline and upland environmental conditions on Virginia Key. The draft report is scheduled to be submitted for review in the next few days and will recommend Federal participation in shoreline and upland environmental restoration efforts at this site.

I am pleased to report that preliminary information reviewed by my staff supports the Jacksonville District's draft recommendation, and we anticipate quick approval for initiation of detailed design and construction efforts. We are also pleased that Miami-Dade County has indicated their interest in being the local sponsor for this project.

The recommended plan of improvements includes shoreline improvements consisting of granite and timber groins and placement of approximately 80,000 cubic yards of beach sand to restore and protect Virginia Key where beach erosion has been accelerated due to previous Federal improvements to the Port of Miami. Shoreline improvements, as mitigation for negative impacts of previous harbor improvements, are authorized under our existing Continuing Authorities Program, Section 111.

Under Section 111 authority, preparation of the required feasibility report and other design studies are a 100 percent Federal cost for the first $100,000, with the balance being cost shared 50 percent Federal and 50 percent local. For construction, the local sponsor will be responsible for all lands and easements while the Federal Government will be responsible for all construction costs. Preparation of the feasibility report and construction plans and specifications is forecast to take 12 months and cost approximately $300,000. The preliminary construction cost estimate is about $4 million. We anticipate awarding the construction contract in late Fiscal Year (FY) 2001, provided that funds are available and significant permit issues involving seagrasses and turtle nesting are resolved without restrictions on the timing of construction activities. Approximately $300,000 in Federal funds is required in FY 2001 to prepare the feasibility report, prepare construction plans and specifications, and award the construction contract.

Also recommended are upland environmental restoration improvements on Virginia Key. About 50 to 100 acres of the island were previously used for dredged material disposal during earlier Federal improvements to the Port of Miami. As mitigation for previous negative impacts, the 905(b) report will recommend removal of invasive exotic plants and restoration of natural wetlands and native coastal plant communities on 150 to 200 acres of the Virginia Key Beach Park area owned by the city of Miami. These upland environmental improvements are authorized under our existing Continuing Authorities Program, Section 1135.

Under the terms of Section 1135, the local sponsor is required to cost share both design and construction. The total project cost will be shared 75 percent Federal and 25 percent non-Federal and includes preparation of an Environmental Restoration Report and construction plans and specifications, credit to the local sponsor for all required lands and easements, and project construction costs. Preparation of the required Environmental Restoration Report and construction plans and specifications is forecast to require 24 months, cost approximately $600,000, and will be completed using 100 percent Federal funds. Local contributions are not required until the start of construction. We anticipate awarding the construction contract in late FY 2002. The preliminary construction cost estimate is about $6 million, so Federal and non-Federal costs will be about $4.5 million and $1.5 million, respectively. Approximately $300,000 in Federal funds is required in FY 2001 to initiate the Environmental Restoration Report.

Section 1135 also authorizes inclusion of recreation features up to 10 percent of project cost with costs shared 50 percent Federal and 50 percent non-Federal. This is important to local interests working to preserve historic recreation features at Virginia Key Beach Park.

This project provides a good example of the value of the Continuing Authorities Program as no new legislation is required to authorize the recommended Virginia Key improvements. However, implementation will depend on availability of funding. Historically, funding for this program has been very limited and competition for available funds has increased in recent years. In recognition of this, Congress has identified specific projects in various appropriations bills to ensure funds are made available for those projects.

The Corps looks forward to working with you on the Virginia Key project. If you need additional information on this project or another Corps effort, please feel free to contact me or my staff.

Sincerely,

Joe N. Ballard
Lieutenant General, U.S. Army
Commanding

Jennie

Jaxie

...ONS
...MITTEES
...URY, POSTAL
...E, AND GENERAL
GOVERNMENT
VA, HUD, AND
INDEPENDENT AGENCIES

Congress of the United States
House of Representatives
Washington, DC 20515–0917

Please Respond To:
☐ 401 Cannon House Office Building
Washington, DC 20515
(202) 225-4506
(202) 226-0777 FAX
☐ 3550 Biscayne Blvd
Suite 500
Miami, FL 33137
(305) 576-9303
(305) 576-9753 FAX

July 25, 2000

Lt. Gen. Joe Ballard,
Chief of Engineers, US Army Corps of Engineers
20 Massachusetts Ave., NW
Washington, DC 20314

Action: CW
(CG signature)
CF: CS-C

Dear Lt. Gen. Ballard:

I write to thank you for your strong support of my effort to restore Virginia Key, FL and for providing the needed funds to complete this project through your Capital Grants Program. I genuinely appreciate your help.

This project is personally important to me. Virginia Key Beach is the site of the former "Colored Beach" in Miami--one of the few places where African Americans could go to swim in Miami in the1940s, 1950s and early 1960s. This project is extremely important to the African American community in Miami because, for decades, it was the only place that we could legally swim and enjoy beautiful Biscayne Bay. I took my own children there to swim.

Virginia Key's restoration has broad support throughout Miami-Dade County. Virginia Key's fragile ecology is in desperate need of restoration. The extensive intrusion of harmful exotics species, the damage caused by Hurricane Andrew, the erosion of the protective beach, and the usage of one of its natural ponds as a waste dump are just some of the elements that have contributed to its deterioration.

I wanted you to know that after our conversation, I spoke to Miami-Dade County Mayor Alex Penelas about the necessary local 35% funding match. He told me that Miami-Dade County would have up to $1.725 million available by next Spring, when hopefully construction can begin on this project.

I look forward to hearing from your staff regarding the details on how we will assure full funding for this project.

In addition, I am enclosing our proposed language for the Water Resources Development Act of 2000. If this is consistent with the two-pronged approach that you mentioned, I would appreciate you communicating your support for this language to the authorizing committees in the House and Senate.

Again, thank you for your assistance. Is there anyway I can convince you to stay a your post for another year?

Sincerely,

Carrie

CARRIE P. MEEK
Member of Congress

CPM/lm
Enclosures

..RIE P. MEEK
..H DISTRICT, FLORIDA

COMMITTEE ON
APPROPRIATIONS

SUBCOMMITTEES
TREASURY, POSTAL
SERVICE, AND GENERAL
GOVERNMENT

VA, HUD, AND
INDEPENDENT AGENCIES

Congress of the United States
House of Representatives
Washington, DC 20515–0917

Please Respond To:

☐ 401 CANNON HOUSE
OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-4506
(202) 226-0777 FAX

☐ 3550 BISCAYNE BLVD.
SUITE 500
MIAMI, FL 33137
(305) 576-9303
(305) 576-9753 FAX

April 14, 2000

COL Joe R. Miller
District Engineer, CESAJ-DE
US Army Corps of Engineers
400 West Bay Street
P.O. Box 4970
Jacksonville, FL 32232

Dear Colonel Miller:

I write to request that the US Army Corps of Engineers conduct a study for the restoration of Virginia Key, a barrier island in Miami, Florida, which is part of a coastal chain that includes Biscayne National Park and extends to the Florida Keys. The study, to be included as an Interim Report in the Biscayne Bay Study, would examine ways to repair coastal structures, nourish the beach, and restore and enhance native environmental features and wetlands.

As a barrier island, Virginia Key has a fragile ecology which is in desperate need of restoration. The extensive intrusion of harmful exotics species, the damage caused by Hurricane Andrew, the erosion of the protective beach, and the usage of one of its natural ponds as a waste dump are just some of the elements that have contributed to its deterioration.

In addition, Virginia Key Beach is the site of the former "Colored Beach" in Miami–one of the few places where African Americans could go to swim in Miami in the1940s, 1950s and early 1960s. This project is extremely important to the African American community in Miami because, for decades, it was the only place that we could legally swim and enjoy beautiful Biscayne Bay. Currently, the beach is in desperate need of nourishment.

As you know, Virginia Key's restoration has broad support throughout Miami-Dade County. This project is one of my highest priorities and it is extremely important to me that this study be completed by next Spring to coincide with the FY2002 Appropriations cycle. I would appreciate all that you can do to expedite the study.

Sincerely,

Carrie P. Meek

CARRIE P. MEEK
Member of Congress

CPM/lm

CARRIE P. MEEK
17TH DISTRICT, FLORIDA

COMMITTEE ON
APPROPRIATIONS

SUBCOMMITTEES
TREASURY, POSTAL
SERVICE, AND GENERAL
GOVERNMENT

VA, HUD, AND
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Please Respond To:
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(305) 576-9303
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Congress of the United States
House of Representatives
Washington, DC 20515–0917

May 5, 2000

WRDA 2000
099

The Honorable Sherwood L. Boehlert
Committee on Transportation and Infrastructure
Water Resources and Environment Subcommittee
B-376 Rayburn HOB
Washington, DC 20515

Dear Chairman Boehlert:

As you continue to work on the Water Resources Development Act of 2000, I ask for your support on the following three provisions.

First, the restoration of Virginia Key, a barrier island in Miami, Florida, which is part of Biscayne Bay, is my highest priority. The enclosed bill language would authorize a project to repair Virginia Key's coastal structures, nourish the beach, and restore and enhance native environmental features and wetlands, pursuant to the completion of a study by the US Army Corp of Engineers that is currently underway. Virginia Key has a fragile ecology which is in desperate need of restoration. The extensive intrusion of harmful exotics species, the damage caused by Hurricane Andrew, the erosion of the protective beach, and the usage of one of its natural ponds as a waste dump are just some of the elements that have contributed to its deterioration. a.

Furthermore, Virginia Key Beach is the site of the former "Colored Beach" in Miami–one of the few places where African Americans could go to swim in Miami in the1940s, 1950s and early 1960s. This project is extremely important to the African American community in Miami because, for decades, it was the only place that we could legally swim and enjoy beautiful Biscayne Bay. Virginia Key's restoration has broad support throughout Miami-Dade County.

Second, I have worked extensively with Administration officials to ensure that minority and limited income populations fully participate in the restoration of the Everglades and that minority contractors have a fair chance of competing successfully for contracts during the implementation phase. I worked with the Administration as it drafted its bill; the result is two provisions regarding minority and disadvantaged individuals. b.

The first provision establishes a goal that no less than 10% of the amounts made available in federal contracts be expended by small businesses owned and controlled by socially and economically disadvantaged individuals. The second provision allows the Secretary of the Army to establish an outreach and monitoring program regarding minority and limited income individuals participation in the provisions from the draft bill for your information.

The Virginia Key restoration project, the 10% goal in federal contracting, and the minority outreach program during the Everglades restoration, are my highest priorities to be included in WRDA 2000. I appreciate your support and efforts to have this language included in the final bill.

Again, thank you for the opportunity to bring them to your attention and I look forward to working with you on this important legislation.

Sincerely,

Carrie

CARRIE P. MEEK
Member of Congress

CPM/lm
Enclosures

SECTION 111

SHORELINE STABILIZATION REPORT
AND
DRAFT ENVIRONMENTAL ASSESSMENT

VIRGINIA KEY
DADE COUNTY, FLORIDA

APPENDIX E

ENVIRONMENTAL

U.S. Army Engineer District
Jacksonville, FL

February 2002

DRAFT
FISH AND WILDLIFE COORDINATION ACT REPORT

United States Department of the Interior

FISH AND WILDLIFE SERVICE
South Florida Ecological Services Office
1339 20th Street
Vero Beach, Florida 32960

March 22, 2001

James C. Duck
Chief, Planning Division
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Duck:

In accordance with the Fiscal Year 2000 Transfer Fund Agreement between the Fish and Wildlife Service (Service) and the Jacksonville District Corps of Engineers (Corps), attached is the Draft Fish and Wildlife Coordination Act Report on the Virginia Key Beach Park Shoreline Stabilization Project, Miami-Dade County, Florida. The Corps requested an evaluation of the environmental effects of securing and placing sand on 0.7 miles of shoreline, constructing several new groins, and replacing old groins along the southeastern coast of Virginia Key. This report is submitted in accordance with the Fish and Wildlife Coordination Act of 1956, as amended (16 U.S.C. 661 *et seq.*)

By copy of this letter, the Service is providing an opportunity for the National Marine Fisheries Service and the Florida Fish and Wildlife Conservation Commission to comment on this draft FWCA report.

If you have any questions, please contact Brad Rieck at (561) 562-3909, extension 231.

Sincerely yours,

Robert T. Pace for

James J. Slack
Field Supervisor
South Florida Ecological Services Office

Enclosures

DRAFT

FISH AND WILDLIFE COORDINATION ACT REPORT

VIRGINIA KEY BEACH PARK SHORELINE STABILIZATION

MIAMI-DADE COUNTY

Submitted to: U.S. Army Corps of Engineers, Jacksonville, Florida
Prepared by: Brad Rieck, Project Biologist
Approved by: James J. Slack, Field Supervisor

U.S. Fish and Wildlife Service
South Florida Ecological Services Office
Vero Beach, Florida

March 2001

TABLE OF CONTENTS

INTRODUCTION

A Federal shore protection project for Virginia Key and Key Biscayne was initially authorized by the 1962 Rivers and Harbors Act. Approximately 1.8 miles of shore on Virginia Key and 1.9 miles of the northerly shore on Key Biscayne were restored in 1969 by placement of 410,000 cubic yards of sand. In 1972, 13 groins were constructed on Virginia Key to reduce sand losses. In 1974, 110,000 cubic yards of sand was placed on Virginia Key in association with Miami Harbor dredging. All of this work was performed north of the project presently proposed.

At present, erosion is most evident for a 1,400- foot section of beach located immediately south of the southernmost groin of the now deauthorized Federal project. Further south, a timber groin system is present. The beach in this 2,300- foot stretch appears to have been relatively stable during the last 50 years. Some of these groins were installed in 1948. In 1956, the remainder were added and some of the original groins were lengthened. These deteriorating groins are approximately 50 long and are spaced 50 to 100 feet apart.

This study is authorized under the authority for the Biscayne Bay Feasibility Study, which was authorized by Congress in 1982. The present study was requested in a letter dated April 14, 2000, from U.S. Representative Carrie P. Meek, Congressional District 17.

The purpose of this draft FWCA report is to assess the impacts to existing fish and wildlife resources in the affected area of the Corps' proposed beach renourishment and groin construction/rehabilitation. The Service has evaluated the study area and provides comments on project impacts, including recommendations for conservation measures.

II. DESCRIPTION OF STUDY AREA

Virginia Key is a barrier island located along eastern Biscayne Bay on the Atlantic coast of Miami-Dade County, Florida, south of Miami Beach and north of Key Biscayne. The shoreline of Virginia Key Beach Park is the specific project site. Shoreline erosion along Virginia Key is reportedly attributed to the Government Cut navigation project at Miami Harbor, located to the north, resulting in an interruption of natural sand migration south.

III. PROJECT DESCRIPTION

Several potential alternatives for shore protection are being considered. These alternatives include constructing rock groins perpendicular to the shoreline, restoring some of the existing timber groins, removing the remaining timber groins, constructing a shore parallel breakwater, and placing beach sand along eroding shoreline.

The plan alternative most likely to address shoreline erosion, according to the Corps, is presently Alternative 3 of the Interim Section 905(b) (WRDA 86) Analysis for Virginia Key, dated July 2000. This alternative considers constructing two 220 foot long groins perpendicular to the shoreline. The groins would be placed approximately 375 feet apart. Location has not been specified. In addition, some of the existing timber groins would be rehabilitated and some removed. Beach nourishment material would consist of approximately 74,000 cubic yards from an upland site, to be distributed along 0.7 miles of shoreline.

IV. FISH AND WILDLIFE RESOURCES

The Service participated in a brief interagency site inspection on January 17, 2001, including the Corps and National Marine Fisheries Service (NMFS). Fish and wildlife habitat that could be affected by this project include the upper beach zone, the surf zone, nearshore seagrasses, and nearshore hardbottom if present.

A. Community Descriptions

Beach

Florida has approximately 744 miles of beaches, mainly along the shorelines of barrier islands. Wind and waves are constantly changing the shape of barrier islands and their beaches. On the east coast of Florida, general patterns of sand transport or littoral drift have been well documented. During winter, net littoral drift is to the south; whereas, during summer, the net transport of sand may retreat slightly to the north if southeasterly winds prevail. Inlets inhibit littoral drift. As a result, beaches on the up-drift or north side of these inlets accumulate sand, while those on the down-drift side are deprived of this sand.

Florida's beaches function as nesting habitat for four species of federally listed sea turtles: the threatened loggerhead turtle (*Caretta caretta*) as well as the endangered green turtle (*Chelonia mydas*), leatherback turtle (*Dermochelys coriacea*) and hawksbill turtle (*Eretmochelys imbricata*). Approximately 40 percent of all loggerhead nesting occurs in the southeastern United States, primarily in Florida. Nesting beaches in Miami-Dade County experience considerable anthropogenic impacts from public use of the beaches. As a result, Miami-Dade County has initiated a program that relocates most nests to suitable areas for monitoring, however those nests laid on Virginia Key are not relocated.

The beaches of Miami-Dade County are typical of other Atlantic Coast beaches in Florida that are subject to ocean waves. Sandy bottom beaches are populated with small, short-lived infauna with high species density and substantial reproductive potential and recruitment. Common species include haustoriid amphipods, decapod crustaceans, bivalves, and spionid worms. These beaches usually have low species diversity, but populations of individual species are often very large. Species such as ghost crabs (*Ocypode quadrata*), mole crabs (*Emerita talipoda*), and polychaetes are highly specialized to survive in this high-energy environment.

Thirteen species of birds nest on Florida's beaches, generally between April and August. All nest on the ground, with the nest consisting of a scrap in the sand. Nesting shorebird populations in Florida have declined due to loss of beach habitat to real estate development. On the remaining few natural nesting beaches, human visitors disrupt nesting birds. Shorebirds such as the western sandpiper may seasonally forage along the Virginia Key shoreline, however shorebird nesting is not expected (L. Coburn; pers. comm. 2001).

Seagrasses

Seagrasses observed along the water's edge, and extending east, during the interagency onsite inspection on January 17, 2001, were shoal grass (*Halodule wrightii*), manatee grass (*Syringodium filiforme*), and turtle grass (*Thalassia testudinum*). Other species could be present, as a thorough survey has not been undertaken.

Seagrasses are a highly productive, faunally rich, and ecologically important habitat within the coastal lagoons, bays, and estuaries of South Florida. In terms of primary productivity, a seagrass bed can produce four to ten times the weight of organic matter as that produced by a cultivated corn field of the same size. Extensive seagrass beds covering hundreds of kilometers may be composed of one to four species. Yet, hundreds to thousands of species of flora and fauna may inhabit these beds, utilizing the food, substrate, and shelter provided by these submerged plants. Rapidly growing seagrass leaves provide food for trophically higher organisms via direct herbivory or from the detrital food web. The canopy structure formed by these leaves offers shelter and protection. This combination of shelter and food availability results in seagrass beds being the richest nursery grounds in South Florida's shallow coastal waters. As such, many commercial and recreational fisheries (*e.g.*, clams, shrimp, lobster, fish) are associated with seagrass beds. Seagrasses have experienced declines in abundance and distribution due to water quality degradation and through the direct loss of habitat related to dredge and fill activities (*e.g.*, navigation channels, marinas) and boating impacts (*e.g.*, propeller scars and groundings). The degradation of water quality is largely the result of point source pollution (*e.g.*, wastewater discharge, agricultural runoff, excessive freshwater discharge), nonpoint source pollution (*e.g.*, stormwater runoff, leaching from septic tanks), and the alteration of adjacent watersheds. The subsequent decline in seagrasses has significantly reduced the fisheries resources in South Florida. Implementation of several protective and restorative measures has improved water quality and radically reduced the rate of habitat loss within South Florida's estuaries. Such measures include the regulation of dredge and fill activities, the elimination of wastewater discharge to surface waters, the treatment of stormwater runoff, and the rehabilitation of adjacent watersheds.

Fauna utilizing seagrass beds range from invertebrates to top level predators in multiple guilds. A few commom species are bittium (*bittium sp.*), sea urchins (*Lytechinus variegatus*), pen shell (*Atrina rigida*), pink shrimp (*Penaeus duorarum*), spiny lobster (*Panulirus argus*), pinfish (*Lagodon rhomboides*), spotted sea trout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellata*), great blue heron (*Ardea herodias*), roseate spoonbill (*Ajaia ajaja*), osprey (*Pandion haliaetus*), West Indian manatee (*Trichechus manatus*), and green sea turtle (*Chelonia mydas*) (USDOI 1982).

Hardbottom

Florida is endowed with several reef types: subtropical coral reefs, live (hard)bottom communities, sabellariid worm (*Phragmatopoma lapidosa*) reefs, vermetid reefs, and deep-water *Oculina varicosa* reefs.

Coral reefs are best developed in the United States in south Florida. Most of the Florida Keys' coral reefs are well known due to the clarity of the water and the popularity of SCUBA diving. Farther north, through Miami-Dade and Broward Counties on the east coast and Collier County on the west coast, water clarity and temperature declines, as do reef-building corals. Continuing north, hard corals are fewer, and "live rock" communities are more prevalent. Live rock communities within the project area are populated by sponges, small (*ahermatypic*) hard corals, tunicates, bryozoans, algae, and sabellariid worms. Live rock communities typically, are also more common in or near the high energy surf zone.

The reefs of Biscayne Bay in this area can be classified as live bottom or live rock communities with scattered hard coral. The South Atlantic Fishery Management Council has developed a Fishery Management Plan (FMP) for Coral, Coral Reef, and Live/Hard Bottom Habitats of the South Atlantic Region. Furthermore, damaging, harming, and killing of live rock is prohibited by the current FMP and all harvesting of live rock has been prohibited since January 1, 1996.

Reef/hardbottom fauna may be divided into sessile and motile components. The sessile component contains the primary producers, some grazers or first order consumers, planktivores, and filter feeders. Hard corals occupy niches as both producer and consumer. Zooxanthellic algae within coral polyps photosynthesize while the polyps themselves capture planktonic organisms for consumption. As with the hard corals, carbon fixed far offsite is also concentrated by tunicates, sabellariid worms, and sponges. These attached filter-feeding organisms contribute to the organic base by trapping nutrient-rich plankton as it is swept past by wave and wind generated currents. Tunicates, sponges, and sabellariid worms add structure to the bottom, providing shelter from predation for many crustaceans and smaller fishes.

Fish and motile invertebrates are attracted to reef/hardbottom by its structure. The numerous crevices, holes, and epibiotic structure provide these organisms with a refuge from larger predatory fish. Structure can also provide barrier to currents and substrate for attaching demersal eggs. In addition to these features, the sessile organisms of the reef provide a large diverse food base on which some fish species feed directly. Others benefit from this indirectly by feeding on invertebrates and other smaller fish which are nurtured by sessile plant material.

Outside of lagoons, nearshore hardbottom areas are the primary natural structures in shallow waters of mainland Florida's east coast and are estimated to have nursery value for 34 species of fishes. (Lindeman and Snyder 1998).

The "food fish" species observed on Miami-Dade County reefs include hogfish *(Lachnolaimus maximus)*, porkfish (*Anisotremus virginicus*), gray snapper (*Lutjanus griseus*), spadefish (*Chaetodipterus faber*), gag grouper (*Mycteroperca microlepis*), and gray triggerfish (*Balistes carpiscus*). Species such as the gray snapper use shallow nearshore reefs as a staging area before recruitment into the offshore commercial and recreational fishery (Stark and Schroeder 1970). All reef fish species are ecologically or scientifically important and some value to recreational divers. Many species are collected for aquariums, such as angelfish (*Pomacanthidae*), butterflyfish (*Chaetodontidae*), wrasses (*Labridae*), damselfish (*Pomacentridae*) and doctorfish (*Acanthuridae*).

The spiny lobster (*Panulirus argus*) is the most popular fishery of the nearshore reefs. After spending its early post-larval life stages in estuarine habitats, young lobsters move to the nearshore reefs, where they may spend a good part of their adult lives. Many of these adults move further offshore seasonally (Lyons *et al.* 1981). Other motile invertebrates include sea urchins, conch, octopus, polychaetes, and decapod crustaceans, which include penaeid shrimp (*Penaeus* spp.), portunid crab (*Portunus* spp.), stone crab (*Menippe mercenaria*), and spiny lobster. Crustaceans consume sessile and epiphytic algae and are, in turn, consumed by higher predators such as grunts (*Pomadasydae*) and snappers (*Lutjanidae*) (Odum 1969). Gastropods graze on algae, thereby passing nutrients and energy produced on the reef up the food chain. Predators of gastropods include other invertebrates, such as the spiny lobster.

Sand source site

Location of the upland sand source has not been verified at this time, therefore existing habitat cannot be characterized and evaluated.

B. Threatened and Endangered Species

The Service is preparing a Biological Opinion pursuant to Section 7 of the ESA to completely address effects to Federally threatened and endangered species.

Sea turtles

Miami-Dade County supports a small percentage (0.6 percent) of Florida's total sea turtle nesting (Meylan *et al.* 1995). Four species are known to nest in Miami-Dade County. The loggerhead sea turtle constitutes by far the largest percentage (approximately 95%) of Miami-Dade County's total nesting activity, with an average of 400 loggerhead nests constructed each year. Small numbers of green, leatherback, and hawkbill turtle nests are also present. The Service believes recommendations based upon the Service's Biological Opinion for the Coast of Florida Study, Region III are applicable for this project. Although this particular beach was not listed as a project proposal in this document, it is similar in nature and is located between listed projects

Miami Beach and Key Biscayne. A summary of the Reasonable and Prudent Measures of the October 24, 1996 Biological Opinion are: (1) substantial monitoring of compaction will be conducted and appropriate corrective actions will be taken, if needed; (2) relocation of nests will be required during periods of nesting activity; (3) escarpments will be leveled, if they occur; and (4) only beach quality sand suitable for sea turtle nesting shall be used. The Service will provide an addendum to this Biological Opinion, which will include updates to several sections and address the construction and rehabilitation of groins.

West Indian Manatee

Biscayne Bay, including waters surrounding Virginia Key, are frequented by the endangered West Indian manatee (*Trichechus manatus*). Area seagrass beds provide foraging habitat for the manatee. Due to shallow water depths, which also prevent manatee foraging nearshore, the Corps does not anticipate water-based project construction. Equipment and labor should remain land-based for this project (M. Dupes, pers. comm. 2001). As such, construction related impacts to manatees are not anticipated. Impacts to seagrasses in water depths conducive to manatee foraging are not anticipated.

V. DISCUSSION

Potential impacts of the proposed beach nourishment and groin work include those to the upper beach zone, surf zone, seagrasses, and nearshore hardbottom if present. Impacts may include burial from actual fill placement and equilibration, burial and suffocation from suspension and settling generated from surf zone washing of the fill material, and damage from groin removal, reconstruction, and new placement.

Service Mitigation Policy

In developing the Service's Mitigation Policy (Federal Register 46 (15), Pg. 7656), the definition of mitigation contained in the Council on Environmental Quality's National Environmental Policy Act regulations (40 CFR 1508.20[a-e]) was used. As such, mitigation can include:

1. avoiding the impact all together by not taking a certain action or parts of an action;

2. minimizing impacts by limiting the degree of magnitude of the action and its implementation;

3. rectifying the impacts by repairing, rehabilitating, or restoring the affected environment;

4. reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and

5. compensating for the impact by replacing or providing substitute resources or environments.

This definition recognizes mitigation as a step-wise process that incorporates both careful project planning and compensation for unavoidable losses and represents the desirable sequence of steps in the mitigation planning process. Initially, project planning should attempt to ensure that adverse effects to fish and wildlife resources are avoided or minimized as much as possible. In many cases, however, the prospect of unavoidable adverse effects will remain in spite of the best planning efforts. In those instances, compensation for unavoidable adverse effects is the last step to be considered and should be used only after the other steps have been exhausted.

The Service's Mitigation Policy focuses on the mitigation of fish and wildlife habitat values, and it recognizes that not all habitats are equal. Thus, four resource categories, denoting habitat type of varying importance from a fish and wildlife resource perspective, are used to ensure that the mitigation planning goal will be consistent with the importance of the fish and wildlife resources involved. These categories are based on the habitat's value for the fish and wildlife species in the project area (evaluation species) and the habitat's scarcity on a national, regional or local basis. Resource Category 1 is of the highest value and Resource Category 4, the lowest. Mitigation goals are established for habitats in each resource category.

The mitigation goal for Resource Category 1 habitats is no loss of habitat value since these unique areas cannot be replaced. The goal for Resource Category 2 habitats is no net loss of in-kind habitat value. Thus, a habitat in this category can be replaced only by the same type of habitat (i.e., in-kind mitigation). The mitigation goal for Resource Category 3 habitats is no net loss of overall habitat value. In-kind replacement of these habitats is preferred, but limited substitution of different types of habitat (out-of-kind mitigation) perceived to be of equal or greater value to replace the lost habitat value may be acceptable. The mitigation goal for Resource Category 4 habitats (considered to be of marginal value) is to avoid or minimize losses, and compensation is generally not required.

Priority habitats in the project area are seagrasses and nearshore hardbottom. These habitats are considered by the Service to be in Resource Category 2, and no net loss of in-kind habitat value is recommended. However, we consider any significant colonies of hard (stony) coral in this area to be Resource Category 1. Research suggests that two species of brain and star coral grow at a rate of approximately 0.5 centimeter per year (Dodge 1987). Based on this information, we estimate it would take these corals, and likely other hard coral species, at least 100 years to reach 1 meter in diameter.

Upper Beach Zone

The upper beach zone supports ghost crabs, which are common occupants of this zone and are at risk of burial. Limited information describes the crabs ability to "burrow up" to the surface if buried. If populations drop after nourishment takes place, it could be attributed to the emigration of crabs responding to a decreased food supply in the disturbed intertidal (surf) zone rather than from burial mortality (Nelson 1985). The upper beach zone also provides nesting habitat for federally listed sea turtles. Potential impacts to these species include loss of nest, reduced nesting activity, and reduced hatchling survival from sand placement, sand compaction, escarpment formation, and sand color and texture changes. The Biological Opinion dated October 24, 1996, for Region III of the Coast of Florida Erosion and Storm Effects Study is applicable to the project area considered for the proposed renourishment. The Service will provide an addendum to this Biological Opinion, which will include updates to several sections and address the construction and rehabilitation of groins with respect to their potential for impacts to sea turtles.

There exists scattered vegetation, observed during site inspection, between the upper beach zone and surf zone in the designated 1400 foot "critically eroded shoreline area" that has managed to thus far survive encroaching wave energy. This includes several isolated black mangroves (*Avicennia germinans*), buttonwood (*Conocarpus erecta*), sea grape (*Coccoloba uvifera*), ficus (*Ficus sp.*), and exotics Brazilian pepper (*Schinus terebinthifolius*) and Australian pine (*Casuarina equisetifolia*). Slightly waterward, this zone is also scattered with dead hardwoods unable to survive encroachment and undermining. It is possible, if shoreline recession continues, that existing vegetation would be subject to loss.

Surf Zone

The surf zone of the beach supports a diversity of amphipods, polychaetes, gastropods, bivalves, and surf zone fishes. In addition to evidence of ghost and mole crabs, staff observed a large number of small marine gastropods in the intertidal zone. Many of the surf zone species, because of their weak swimming capabilities, burrowing and/or cryptic nature, will be negatively impacted by the beach nourishment from the sand "dump". New recruitment must come from juveniles or adults which migrate to the area. Increased sediment load may affect the respiration of some species, which could cause suffocation and the loss of these individuals to the system. Information on surf zone fishes is limited but generally states that most fish will flee and avoid the disturbed area and will return within a few months. Nelson (1985) suggests that loss of habitat may be more harmful to fish than suspended sediment loading, which could clog their gills. Most surf zone fish may tolerate an elevated level of turbidity, but burrowing fish are at greater risk from burial.

In general, sandy beaches are populated by small, short-lived organisms with great reproductive potential. As a result, these communities tend to recover quickly from environmental disturbances. The effects of this beach nourishment project on the beach zone fauna will depend primarily on the quality of the nourishment material. If the sand selected to be used for this project meets recommended specifications, recovery of the beach fauna should occur within one year.

Seagrasses

As per onsite observations and maps provided by Miami-Dade County Environmental Resource Management (DERM), the nearshore westerly seagrass edge meanders along the ebb tide line. Potential impacts to seagrasses resulting from beach nourishment include direct burial at the toe of fill or equilibrium toe of fill, coverage by agitated finer suspended sediments (beach wash) settling nearshore, stress from associated elevated turbidity. Potential impacts to seagrasses resulting from groin work include damage from removal and replacement of timber groins as well as the installation of new groins.

It is our understanding that it is the Corps' desire to limit project impacts to only those seagrasses in the immediate vicinity of the old timber groins slated for removal. Beach fill is planned for deposition above high water. However, due to lack of beach and groin construction plan specifics as related to seagrass boundaries, the Service cannot evaluate direct or indirect impacts to seagrasses at this time.

Where impacts cannot be avoided, the Service recommends mitigation through the creation of similar resources to those which are lost. Mitigation offsets should, as a minimum, be a ratio of 1 to1 with the addition of a risk factor multiplier and a temporal lag multiplier.

It should be noted that should sand actually accrete between groins over time and cover seagrasses presently existing between these groins, compensatory mitigation should also be required.

Nearshore hardbottom

Impacts to nearshore hardbottom, if present, could include direct burial through sand placement and excessive turbidity and sedimentation from wave washing of the nourishment material. Despite frequent scouring, this habitat should be recognized as a valuable fishery resource. The South Atlantic Fishery Management Council's Fishery Management Plan calls for avoiding impacts to this important resource. Where impacts cannot be avoided, the Service recommends mitigation through the creation of similar resources to those which are lost. Mitigation offsets should, as a minimum, be a ratio of 1 to1 with the addition of a temporal lag multiplier.

Due to lack of information, the Service cannot presently evaluate direct or indirect impacts to hardbottom communities, if present. We request a detailed survey providing location, character, and extent of any nearshore hardbottom east of the project beach.

Borrow Site: upland sand specifications

The Corps' Miami-Dade Alternate Test Beach proposal includes the following sand specifications (also see Appendix 1). These specifications and recommended amendments in the Recommendations section of this report, as also included in our FWCA report for the Alternate Test Beach project, should be applicable to Virginia Key beach.

1. 99% of the material must pass through a # 3/8 sieve (9.51 mm) and shall contain no material larger than a # 3/4 sieve (19.00 mm).
2. The average mean grain size required is 0.30 mm, but not exceed 0.55 mm.
3. Sand will be composed of quartz and/or carbonate with no more than 20 percent sand of other mineralogical composition.
4. Silt content of less than 5 percent [passing #200 sieve (.074)].
5. Phi Standard Deviation values from 0.50 phi to 1.75 phi.
6. Free of debris, sharp rocks and pebbles, concrete rubble, clay, and organic material.
7. Sand color shall be similar to the existing beach and within the range on the Munsell Soil Color chart- Hue: 2.5 YR; 5 YR; 7.5 YR; 10 YR; 2.5 Y; 5 Y; Chroma: 1, 2, or 3; Value: 6, 7, or 8.
8. Phase 1 Hazardous Toxic and Radioactive Waste (HTRW) Evaluation will be conducted at the potential borrow sites to insure the material does not contain hazardous material. If acceptable, the material will be tested further for radioactive isotopes and various other environmental contaminants.

Threatened and Endangered Species

Due to unknown sand source and specifications, beach design, and groin specifics for this project, the Service, at this time, cannot assess potential effects on listed sea turtles. The upland sand source may not be in spirit with the Reasonable and Prudent Measure of the Coast of Florida Biological Opinion which addresses beach quality sand and its suitability for sea turtles, from nesting to hatchling emergence. The Service has provided recommendations for revising the Corps' current sand specifications in the February 2000 Draft FWCA report for the Miami-Dade Alternate Test Beach in order to ensure suitable beach material is utilized. Virginia Key beach should be subject to these recommendations as well.

Continued consultation under section 7 is necessary to address sand suitability and groin construction as they relate to sea turtles. Additionally, it may be appropriate to initiate consultation for possible effects to listed species which may be associated with the upland sand source, depending on location. Areas identified as Alternative Sand Source Locations in the Coast of Florida Study EIS (Pg. EIS-25) indicate quarries may be located in environmentally sensitive areas, such as the Lake Wales Ridge.

VI. RECOMMENDATIONS

Sand Specifications

During review of the upland sand source specifications for the Alternate Test Beach project, the Service provided the following recommendations. These recommendations should be applicable to Virginia Key beach nourishment.

1. Upland material should be compared to the historic natural native beach for compatibility and similarity;

2. Clarify mean grain size by including the sorting coefficient in the discussion;

3. Specify that quarried limestone crushed to meet grain size specifications is prohibited.

4. Turbidity issues and concerns can be addressed by including the following:

   (a) Remove the words "whole or" in the shell fragments to describe acceptable shells. Whole shells that are sand-sized are very fragile, break down easily and produce mud. These "whole" shells are not durable, and the shells should be defined as fragments of mollusk shells, and excluding Halimeda, benthic foraminifera, etc. These quiet-environment "shells", break down very easily on a high energy beach.

   (b) Test carbonates for durability by requiring a tumbling barrel test with quartz included in the barrel, to simulate abrasion on the beach itself. Evaluate the remaining material.

   (c) Prior to transportation the material should be wet separated to wash out 90% of the fine material that is less than 200 microns in size. Utilization of on-site retention ponds should greatly reduce turbidity during and post-construction.

   (d) Modify the sieving requirements to specify that they be wet sieved, with the tap water (not distilled water) retained, decanted, dried and weighed so there is an accurate percentage of muds calculated. Carbonate muds when dry will sieve as grains and not as mud.

   (e) Require a settling tube analysis be conducted with the sieving analysis. This would show whether the non-quartz grains settle like quartz of the same size. The tube should be calibrated to quartz grains at 20 microns vs. the 62 micron standard. Sediments less than 20 microns are more likely to remain in suspension longer and are easily re-suspended.

   (f) Require a final 0.5 or 1.0% silt content equal to or less than 20 microns as opposed to the 5% in the current specifications; this may be achieved if the above recommendations are implemented.

5. Restore a quartz dominated beach by limiting the percent carbonate to 30% to reflect the historic native beach composition.

6. Add the #35 sieve (0.50 mm) to the sediment sieve analysis to give more precise grain size distribution.

7. Prior to the final site selection of the upland sand source, the Service requests to review the sediment data obtained from the candidate sites. In addition, the Service requests the opportunity to provide our recommendations and site preference.

The Service also has concerns regarding possible contamination issues associated with any upland sand source. Proper analysis and evaluation should be implemented.

Beach zone

1. All exotic vegetation should be removed from the existing shoreline and immediately adjacent uplands.

2. A dune should be constructed along the landward portion of the proposed beach fill. The dune should be constructed as closely as possible to a natural back beach on this island, and stabilized and maintained with native dune vegetation. This system should be included as an element in the monitoring plan.

Seagrasses

We have reviewed seagrass mapping performed by Miami-Dade County DERM and compiled in February. In order to quantify and evaluate impacts to seagrasses, the plotted westerly seagrass edge needs to be integrated and illustrated with construction specifications. These include toe of beach fill, equilibrium toe of beach fill, new groin placement, and old timber groin replacement.

1. Submit additional survey information including species composition, density, and extent of area seagrasses so that we may complete our impact evaluation.

2. Restrict the eastward placement and design contouring of beach fill such that the equilibrium toe of fill does not cover seagrasses.

3. Select/wash nourishment material so that suspension and nearby redeposition of fine/unsuitable material on seagrasses, due to rain or wave energy, does not occur.

4. To the extent possible, avoid damage to seagrasses in the removal and replacement of timber groins.

Nearshore reef

A survey targeting characterization and extent of nearshore hardbottom should be submitted to the Service. If resources are present, the Service recommends that the Corps provide plans for avoidance, minimization, and mitigation of any quantifiable impacts.

Mitigation

Due to lack of information, the Service cannot evaluate mitigation for resource impacts. Compensatory mitigation plans should be submitted for unavoidable impacts to seagrasses and nearshore hardbottom.

Monitoring

The Corps should incorporate a turbidity and sedimentation monitoring program into the design and construction specifications for the project. The monitoring program should include a series of appropriate monitoring stations along the beach proper, surf zone, and nearshore. The monitoring program should require surveys to be conducted before, during, and after construction. Separate monitoring plans should encompass dune establishment and planting, beach profile and toe of fill extension, adjacent seagrasses, and any nearshore hardbottom. Monitoring associated with sea turtles will be addressed in the Service's forthcoming Biological Opinion.

Research

We recommend that the Corps research a temporal factor, incorporating a functional equivalency assessment, for insertion in mitigation calculations, for ratio/quantification evaluation here and in future projects. The Service recommends Habitat Equivalency Analysis: An Overview (NOAA, Damage Assessment and Restoration Program, 1995) as one reference. Another reference, based on this concept, is the Temporal Lag Table found in Section 5c of the Corps sponsored Joint State/Federal Mitigation Bank Review Team Process For Florida (October 1998). The Service will assist in this initiative.

Service site evaluation

Although the Service has visited the site, a detailed inspection was not conducted. It is recommended that the Corps submit the requested information pertaining to and integrating existing site character and construction plan details, after which the Service and NMFS will revisit the site prior to submission of a final FWCA.

VII. SUMMARY OF SERVICE POSITION

The Service is aware of the compressed time frame associated with the Corps' project planning for Virginia Key Beach Park shoreline stabilization; however, until we receive the information requested in this report, we will be unable to deliver the final FWCA report on this project. Specifically, we request the following:

1. Sand source candidates with sediment data for each;

2. New groin location and design and existing groin rehabilitation design, both clearly compared with the mapped western seagrass edge;

3. Beach nourishment design plan views and cross-sectionals showing profile, toe of fill, and equilibrium toe of fill clearly compared with the mapped western seagrass edge;

4. Additional benthic survey(s) providing seagrass character and extent, as well as hardbottom character and extent if present.

5. Conceptual mitigation plan for seagrasses and hardbottom, if present.

The Service anticipates being able to provide a final FWCA report within thirty (30) days of receipt of this information.

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FIGURES

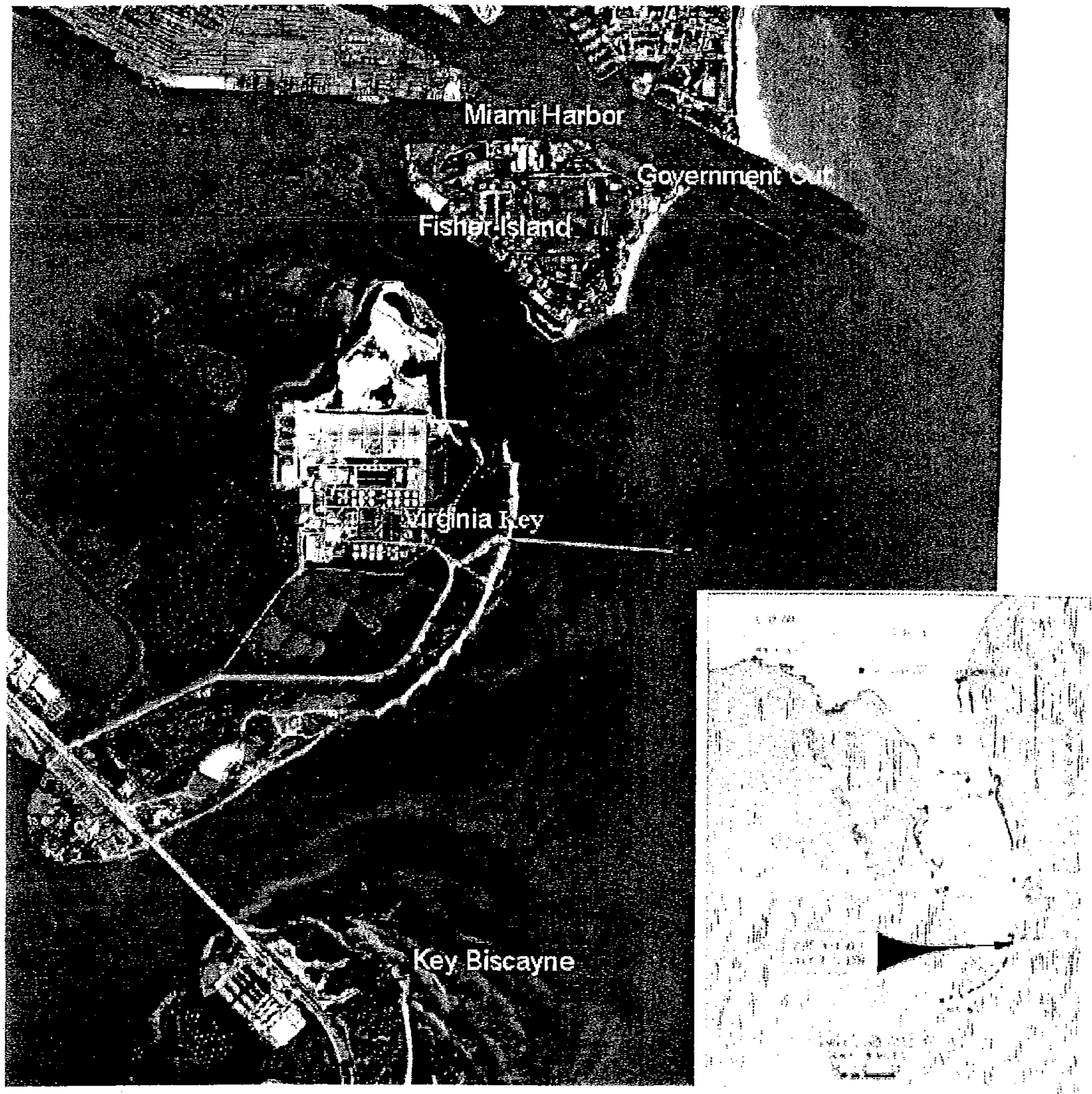
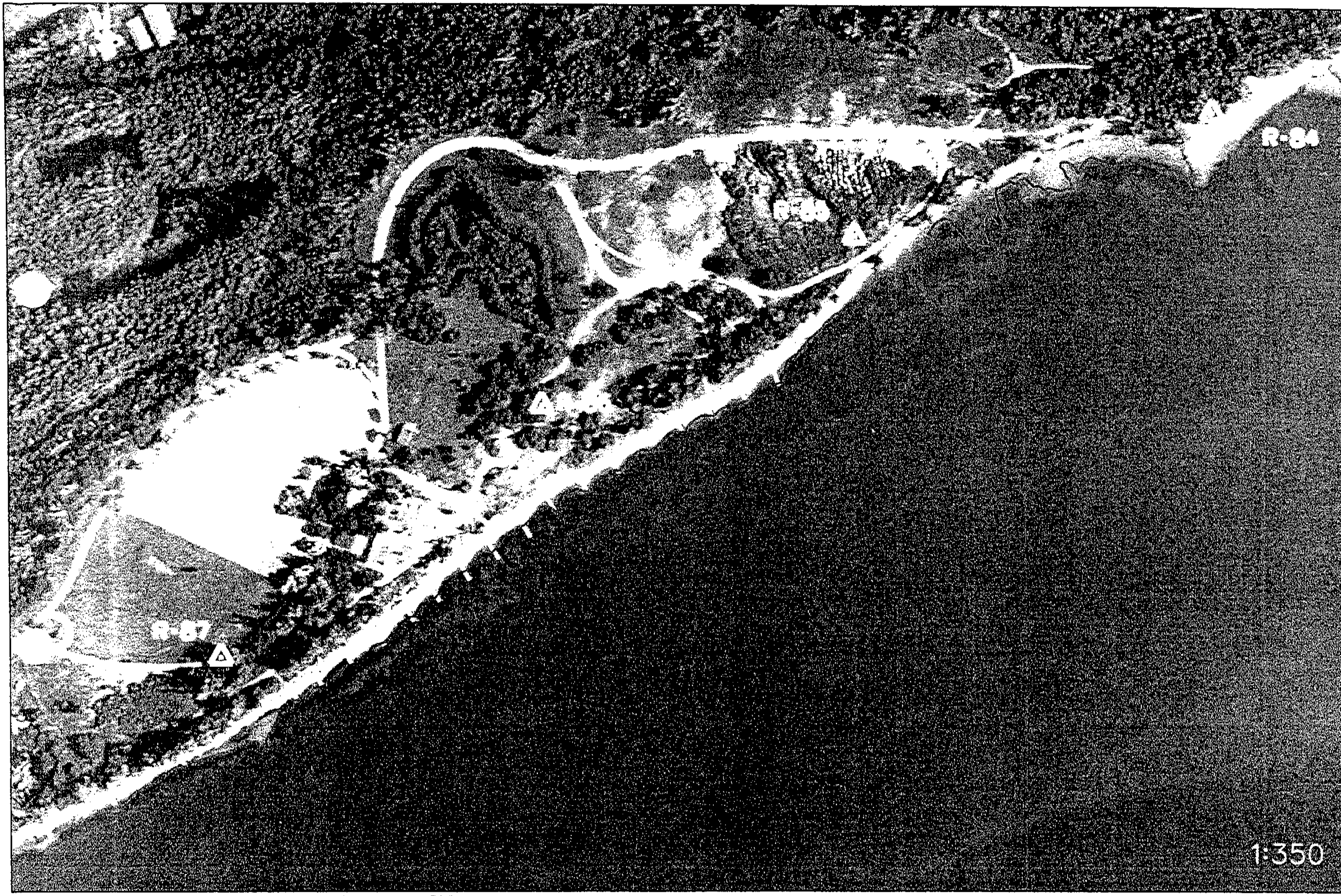


Figure 1. Project Area Map



E:\projects\virginia\C044S1.dgn 02/12/01 03:14:34 PM

Figure 2

APPENDIX

BEACH FILL

1. PAYMENT

Payment for sand fill shall be made on the basis of the quantity of sand placed within each Acceptance Section, as measured by the volume of sand within the template shown on the plans. The total quantity may be modified depending on the Mean Grain Size of the sand delivered, according to these specifications and the Bid Schedule. During placement and prior to measurement, the fill sand must have been flooded to consolidate the sand, according to these specifications. Acceptance Sections will not be accepted by the Government until all Mean Grain Size analysis and calculations has been completed for that Acceptance Section, verifying the Mean Grain Size of sand delivered, and thus the proper quantity of sand for that Mean Grain Size, as shown on the Bid Schedule.

2. ACCEPTANCE SECTIONS

Acceptance Sections shall be every 500 feet along the project beach.

3. SAND SOURCE

This project is a test fill for a generic upland source of sand. No offshore sand sources shall be an acceptable source.

4. SAND FILL MATERIAL

The Contractor is responsible for providing a source, delivery and spreading of beach compatible sand that meet the following specifications. The sand supplied shall be naturally created. The sand may be processed, but manufactured sand is not allowed. Contractor's offering blended sand shall submit a Blending Plan, showing the method the sand components will be thoroughly mixed before final placement on the beach. The project requires the contractor to Bid sand with an average mean grain size of 0.30 mm or greater. The sand will be placed and shaped on the beach to fill the construction template shown in the plans, except as modified by the Mean Grain Size. Final beach fill shape shall parallel the construction template shown in the plans.

The project will benefit from placement of coarser sand, and incentive is provided to bid the coarsest sand available. The incentive is in two parts:

1) The project design beach must be built to the template shown on the plans. A price incentive for an increased Average Mean Grain Size is offered for that portion of the fill quantity (52 percent of the total quantity).
2) For the advance nourishment portion of the project fill (48 percent of the total quantity), a reduced quantity incentive for an increased Average Mean Grain Size is offered.

Appendix 1

If the contractor can provide sand with an Average Mean Grain Size of 0.33mm or coarser, the corresponding Bid and placed quantity will be reduced. Placed volume reduction for coarser sand is available on the Bid Schedule, up to a maximum allowable Mean Grain Size of 0.55 mm. The contractor should select the largest (coarsest) Mean Grain Size he can provide. **The contractor is warned that failure to achieve the grain size class selected on the Bid Schedule, by delivering a finer Mean Grain Size sand, will increase the quantity of sand required for delivery to the project.** Correspondingly, a coarser sand delivered than selected on the Bid Schedule will reduce the volume of sand required. The price incentives shall be paid after determining the Average Mean Grain Size of the completed Acceptance Section. Table 1 shows the coarse sand price and quantity incentives.

TABLE 1
COARSE SAND INCENTIVES

	DESIGN BEACH		ADVANCE NOURISHMENT		
MEAN GRAIN SIZE (mm)	52% OF TOTAL QUANTITY	% PRICE INCREASE	48% OF TOTAL QUANTITY	% VOLUME REDUCTION	TOTAL QUANTITY CY
0.30	208,000	0%	192,000	0%	400,000
0.33	208,000	2%	159,360	17%	367,360
0.36	208,000	5%	140,160	27%	348,160
0.40	208,000	8%	126,720	34%	334,720
0.45	208,000	10%	119,040	38%	327,040
0.50	208,000	15%	115,200	40%	323,200
0.55	208,000	19%	113,280	41%	321,280

5. CHARACTER OF MATERIAL

The character of the sand to be supplied by the Contractor shall meet the following physical specifications:

- Composed of quartz and/or carbonate with no more than 20 percent *sand of other mineralogical composition.*

- *The carbonate sand grains allowable under this specification are naturally occuring, durable and solid carbonate grains. Many carbonate grains have excessive internal pore space dramatically reducing the grains density and durability. Carbonate grains* *delivered under this specification shall be 90 percent durable and solid carbonate grains. Internal pore space shall not exceed 10 percent*

> *Whole and broken mollosk shells from the beach environment are durable and solid carbonate grains. Due to the platey nature of shells and shell fragments, no more than 60% of the sand (quartz or carbonate) shall be whole or broken shell.*

- Silt content (passing #200 sieve (.074mm)) of less than 5%.

- 99% of material must pass 3/8 inch sieve and shall contain no material larger than the 3/4 inch sieve.

- Average mean grain size greater than or equal to 0.30 mm and less than 0.55 mm.

- Phi Standard Deviation values from 0.50 phi to *1.75 phi.*

- Free of debris, sharp rocks and pebbles, concrete rubble, clay, and organic material.

- Sand color shall be similar to the existing beach. Based on the Munsell Soil Color Chart, color must be within the range:

  HUE of: 2.5 YR, 5 YR, 7.5 YR, 10 YR, 2.5 Y, 5 Y
  CHROMA of: 1, 2, or 3
  VALUE of: 6, 7, or 8.
  This color specification eliminates strongly colored or dark sand.

6. SUBMITTALS

Sand source information that shall be submitted with the proposal is:

1) the name, location and physical address of the proposed sand source;
2) written evidence that the proposed sand source is permitted under local, State, and other authorities, as applicable;
3) a grain size distribution of the proposed sand source as determined and reported by a Certified Testing Laboratory. The grain size data shall supply all information required for grain size distribution data under GRAIN SIZE REPORTING requirements.
4) a 1 to 3 pound sample of the proposed fill material; and
5) evidence that the proposed sand source contains sufficient quantity of acceptable material for the construction of the work.

Samples shall be provided in sealed plastic containers, either jars or bags, clearly marked with the name of the Contractor, the name of the source and any other identifying information.

The submitted grain size distribution data and the sample of the proposed sand source (including its color and texture) shall be representative of the typical nature of the entirety of the proposed sand fill. The Government will retain the submitted documents and samples.

7. SAND FLOODING

If the sand is placed in a state that is not completely saturated by hydraulic placement, the Contractor must saturate the dry placed sand to effect consolidation equal to hydraulic placement. No more than 100 cubic yards of sand at a time shall be placed on the beach without saturating. Enough water must be used to completely saturate the sand, not less than 100 gallons of water shall be available for each cubic yard of sand placement. Run off water shall be controlled so as not to run off the project limits on the upland side and not to run directly to the ocean forming gullies, eroding the fill sand.

8. CALCULATION OF AVERAGE MEAN GRAIN SIZE

The Mean Grain Size and Phi Standard Deviation shall be determined by Method of Moments Statistics calculated from sieve analysis of the proposed sand source. A Certified Testing Laboratory shall perform laboratory testing in accordance with ASTM – D422. The Method of Moments Statistics shall be calculated according to the instructions contained within this section.

Mean grain size and phi standard deviation are statistical measures of the textural character of a sample of sand, corresponding to the mean and standard deviation of a statistically normal population (example: sand grain sizes). Laboratory sieving of sand provides the data for calculation of the mean grain size and phi standard deviation. There are several methods of calculating these statistics. For the purposes of this contract, Mean Grain Size and Phi Standard Deviation shall be calculated by the Method of Moments. The method of calculation is included in this section. The Average Mean Grain Size refers to the average of the Mean Grain Sizes calculated for individual samples sieved in the laboratory. The Average Mean Grain Size shall be used to evaluate price and quantity incentives for this contract.

9. GRAIN SIZE REPORTING

The grain size distribution information shall be based upon ASTM – D422, using U.S. Standard sieve sizes 3/8", 4, 8, 16, 30, 40, 50, 70, 100, 140, 200, 230. All gradation curves shall be submitted on ENG Form 2087, sample appended to this section. All title information shall be filled out with project name, date, sample number, location sample obtained, unified soil classification, percent silt passing the No. 200 sieve (0.074mm), percent silt passing the No. 230 sieve (0.063mm) and Method of Moments Mean Grain Size and Phi Standard Deviation. Each curve shall state what Mean Grain Size class the sample meets, according to the Bid Schedule. A tabulation of the laboratory results of the cumulative percent retained on each sieve by weight shall be provided with each gradation curve. Samples from the sand source shall be numbered consecutively. Samples from the project site shall be identified with the Acceptance Section, numbered consecutively for each Acceptance section, and a station and range location.

10. CERTIFIED TESTING LABORATORY

Certified Testing Laboratory refers to a geotechnical testing laboratory qualified under ASTM E329-95c standards and certified by AASHTO (American Association of State Highway and Transportation Officials) National Voluntary Accreditation Program; or MMRL (AASHTO Materials Reference Laboratory accreditation; and personnel qualified by NICET (National Institute for Certification of Engineering Technicians).

11. MEAN GRAIN SIZE AND PHI STANDARD DEVIATION CALCULATION USING THE MOMENT METHOD

The equations for calculating the Mean Grain Size and Phi Standard Deviation using the moment method are as follows:

Mean Grain Size $$M = \frac{\Sigma fx}{n}$$

Phi Standard Deviation $$\sigma = \sqrt{\frac{\Sigma (x - M)^2}{n}}$$

Use of these equations to calculate the moment method values is illustrated in Table 2. Column A is the sieve size used, Column B is the corresponding sieve opening in millimeters, and Column C is the sieve opening in phi. The phi values are used in the calculation.

Sieve analysis measures the percent retained on each sieve size by weight (Column D). Column E (x) is the midpoint value in phi between adjacent sieves. Column F (f) is the percent retained by the smaller of adjacent sieves. Column G is the product of Column E and F (x * f). The sum of the values in Column F is n, sum of the percent retained on the smallest sieve used. This value will generally be less than 100%, as some fine material passes through all the screens. The sum of the values in Column G is Σfx, and its division by n produces the mean grain size in phi units of measure. The millimeter (mm) value is calculated as follows:

$2^{-phi} = mm$ Example: $2^{-1.25\ phi} = 0.42$ mm

Columns H and J are used to calculate the Phi Standard Deviation (σ) value of the material. If a sieve size is not used in the testing process it should be completely eliminated from the calculation table.

12. QUALITY CONTROL SAMPLING

The Contractor shall perform sampling that includes no less sample collection than described in the following plan. The Contractor shall conduct all testing in a location accessible to government inspectors. The Contractor shall include the sampling and testing procedure in his Contractor's Quality Control Plan for government review and acceptance within ten days of notification of acceptance of Bid. The Quality Control Plan shall include the name, address and point of contact for the Certified Testing Laboratory to be used for all grain size analysis. The location of the testing facility to be used for this contract shall also be included in the Quality Control Plan. Gradation test results shall be turned in daily with the daily quality control reports. Each sample collected shall be approximately one pound in weight and obtained from a single location. **All laboratory test results shall be reported to the Government.**

Sampling at the Sand Source

Sand samples for laboratory testing shall be collected at the sand source at the rate of one sample for every 2000 cubic yards of sand to be transported. Sampling and testing shall be completed before the sand is transported to the project site, and shall be representative

Table 2

CALCULATION OF MOMENT METHOD FOR MEAN GRAIN SIZE AND PHI STANDARD DEVIATION

A	B	C	D	E	F	G	H	I
U.S. STANDARD SIEVE	GRAIN SIZE mm	PHI	CUMULATIVE PERCENT RETAINED*	* Cumulative Percent Retained is example results of laboratory sieving of a sand sample.				
				x	f	fx	$(x\text{-}M)^2$	$f(x\text{-}M)^2$
3/4	19.00	-4.25	0.0%					
				-3.75	0.9%	-0.034	28.084	0.253
3/8	9.51	-3.25	0.9%					
				-2.75	3.8%	-0.105	18.498	0.703
4	4.76	-2.25	4.7%					
				-1.75	4.7%	-0.082	10.901	0.512
8	2.38	-1.25	9.4%					
				-0.75	9.5%	-0.071	5.298	0.503
16	1.19	-0.25	18.9%					
				0.25	10.5%	0.026	1.694	0.178
30	0.595	0.75	29.4%					
				1.00	4.5%	0.045	0.303	0.014
40	0.420	1.25	33.9%					
				1.50	5.3%	0.080	0.002	0.000
50	0.297	1.75	39.2%					
				2.00	9.0%	0.180	0.203	0.018
70	0.210	2.25	48.2%					
				2.50	12.3%	0.307	0.899	0.111

100	0.149	2.75	60.5%					
				3.00	24.8%	0.744	2.098	0.520
140	0.105	3.25	85.3%					
				3.50	10.6%	0.371	3.815	0.404
200	0.074	3.76	95.9%					
				3.88	1.1%	0.043	5.417	0.060
230	0.063	4.00	97.0%					
SUM				n=	97.0%			
SUM				Σ=		1.50		3.276
MEAN GRAIN SIZE (PHI)				**M(phi) =**		**1.55**		
MEAN GRAIN SIZE (mm)				**M(mm) =**		**0.34**		
PHI STANDARD DEVIATION				σ=				**1.84**

of the sand being delivered to the project. Each day's samples Mean Grain Size and Phi Standard Deviation shall be averaged and the running average recorded on the gradation curve, along with the individual sample Mean Grain Size and Phi Standard Deviation. A new average shall be started each day. The Average Daily Mean Grain Size shall be used as an indicator for the Mean Grain Size for the sand proposed on the Bid Schedule and being delivered to the project. No individual sample Mean Grain Size shall be less than 0.25 mm. Any materials not meeting the Mean Grain Size requirements shall not be transported to the project site. Any materials not meeting the Contractor's Bid Mean Grain Size delivered to the project site shall fall into the lower Mean Grain Size class, and appropriately more sand shall be delivered.

Sampling at the Project Site

Sand samples for laboratory testing shall be collected at the project site. Sand samples shall represent the fill material only, avoiding existing beach sand below the project fill. Sand samples shall be collected from each beach fill Acceptance Section. Sand samples shall be collected at the rate of one sample representing 500 cubic yards of sand delivered. This represents approximately 100 samples taken per 500 foot Acceptance Section. The samples shall be collected on a regular sampling grid covering the entire Acceptance Section, and the location recorded on the gradation curve. The plan of beach sampling shall be submitted with the Contractor's Quality Control Plan. All sample collection in an Acceptance Section shall be distributed temporally over the entire filling operation. Half of the samples shall be collected during filling of the Acceptance Section, when the fill is approximately less than half of the final grade. The second half of the samples shall be taken from the surface of the completed Acceptance Section. Samples shall not be collected from the surface, but 6 inches below the ground surface. Before an Acceptance Section is surveyed for final payment and accepted by the government, all sample laboratory analyses shall be completed and submitted to the Government. All individual sample Mean Grain Size and Phi Standard Deviation shall be tabulated. The tabulation shall include sample identifying information including Acceptance Section, sample number and date. The Average Mean Grain Size and

Average Phi Standard Deviation for each Acceptance Section shall be calculated from and indicated on the tabulation sheet. The Average Mean Grain Size from the sample analysis for each Acceptance Section shall be compared to the Bid Schedule Mean Grain Size class, and verify that the appropriate quantity of sand has been delivered for the Mean Grain Size of the sand in that Acceptance Section. The survey of the Acceptance Section will verify the quantity of sand delivered. **The total quantity of sand in an Acceptance Section shall match the quantity shown on the Bid Schedule for the Mean Grain Size class of sand indicated by the Average Mean Grain Size of sand delivered to that Acceptance Section.**

13. PERMITS

The Contractor shall be responsible for obtaining all applicable permits for the sand source. As part of the proposal, the contractor shall submit evidence satisfactory to the Government that the sand source to be used for the project is permitted by local, State, and Federal authorities, as applicable. The Contractor is likewise responsible for obtaining all applicable permits and licenses for the transport of equipment and material undertaken as part of the work.

The Government shall obtain permits for the placement of the fill sand along the project beach area. By acceptance of the contract, the Contractor agrees to abide by all applicable conditions of the permits.

14. ENVIRONMENTAL QUALIFICATIONS

GENERAL REQUIREMENTS FOR BORROW SOURCES

It is important that any material to be used for a Dade Co. sand borrow source be considered to be as clean as what exists on Dade beaches or is normally used for playground quality sand. A Phase I HTRW (Hazardous Toxic and Radioactive Waste) Evaluation to meet the requirements of ASTM E-1527-97 shall be performed on the borrow source material. If the borrow site contains HTRW materials or is suspected of containing hazardous materials, fissionable materials, environmental contaminants or otherwise toxic materials it shall not be used as a borrow source. Materials passing these evaluation criteria will be tested as provided below and testing results provided to the Government.

REQUIREMENTS FOR RADIOACTIVE ISOTOPES:

Radiation levels and radioactivity content shall be measured for the borrow material and for beach area. The borrow area and the beach placement area shall be surveyed in a pattern approved by the Government as described below. The background radioactivity and radiation levels (milli-roentgens/hour) of the borrow area vs. the beach site shall be compared. The levels of contaminant (radioactivity content in pico-curies/gram) in borrow material cannot exceed the mean levels existing at the beach placement area. If radioactivity levels of the source material exceed the mean naturally occurring radiation levels at the beach area, the site shall not be used as a borrow source. These radiological surveys and analysis shall consist of the following:

Radiation surveys are to be taken at the beach and borrow sites. The radiation levels shall be presented in graphical and tabular form. These surveys shall be taken at waist level. Additionally, samples from the beach and borrow site shall be analyzed for radioactivity levels and be reported in pico-curies per gram. The measurements shall also fall within _1_ standard deviation or suspect high values will be determined to be the most conservative representation of the results. The results of the radioactivity (pico-curies per gram) shall be reported in graphical and tabular form.

The resulting beach background radiation level shall not be increased by more than 20 micro-roentgens/hr. This is to be determined by gamma radiation surveys (with the probe at waist level) taken both before and after the beach material placement.

Gamma spectroscopy analysis for Radium 236 shall be performed at the beach site and at the potential borrow site. The placement of borrow material shall not allow the resulting composite radioactivity at the beach (determined by the gamma spectroscopy) to increase by more than 5 pico-curies/gram.

Methodology for radioactivity content to be used for individual sample analysis shall be EPA method 9310 for alpha and beta emissions.

Methodology for Gamma Spectroscopy analysis shall be EPA method-----------------

The Contractor shall provide reports to the Government demonstrating their evaluation of the above criteria and provide all data including all radiation values taken.

REQUIREMENTS FOR ENVIRONMENTAL CONTAMINANTS

The Contractor shall provide reports to the Government demonstrating their evaluation of the below criteria and provide all data including all chemical values determined. The data shall be provided in graphical and tabular format. It is anticipated that background level of contaminants for Dade County beaches is essentially zero or below detection limits. Should contaminants be detected in borrow material the levels of contaminant in borrow material cannot exceed the mean levels existing at the beach placement area in samples taken as described below. These measurements will consist of the following chemical testing of the borrow material and elutriates;

Total Recoverable Petroleum Hydrocarbons (TRPH), EPA 9071A or EPA 8440

Heavy metals (As, Ba, Cd, Cr, Hg, Pb, Se), EPA method 3051 (Use graphite furnace method for each metal except Hg which has own method)

Volatile Halogenated Organics (Cl-, Br-), EPA method 8021A

Polycyclic Aromatic Hydrocarbons (BTEX), EPA method 8021A

Elutriate Preparation shall be by the method provided in EPA/CE 81-1. Testing for all above contaminants shall be performed on elutriates.

If contaminant levels of the borrow material exceed the mean naturally occurring contaminant levels at the beach area, the site shall not be used as a borrow source. The measurements shall also fall within _2_ standard deviation or suspect high values will be determined to be the most conservative representation of the results. Elutriate values shall be compared to State Water quality standards to determine whether runoff will violate State standards.

SAMPLING LOCATIONS FOR ENVIRONMENTAL CONTAMINANTS

Samples to be taken for the above requirements shall be taken every 1000 feet as needed in the beach placement area, for representative beach quality samples, and in spots considered to be representative of every 50,000 cubic yards of the borrow material. Representative samples from all sites shall be taken in a pattern and locations approved by the Corps.

APPENDED TO SECTION:
````````````````GRADATION CURVE, ENG FORM 2087
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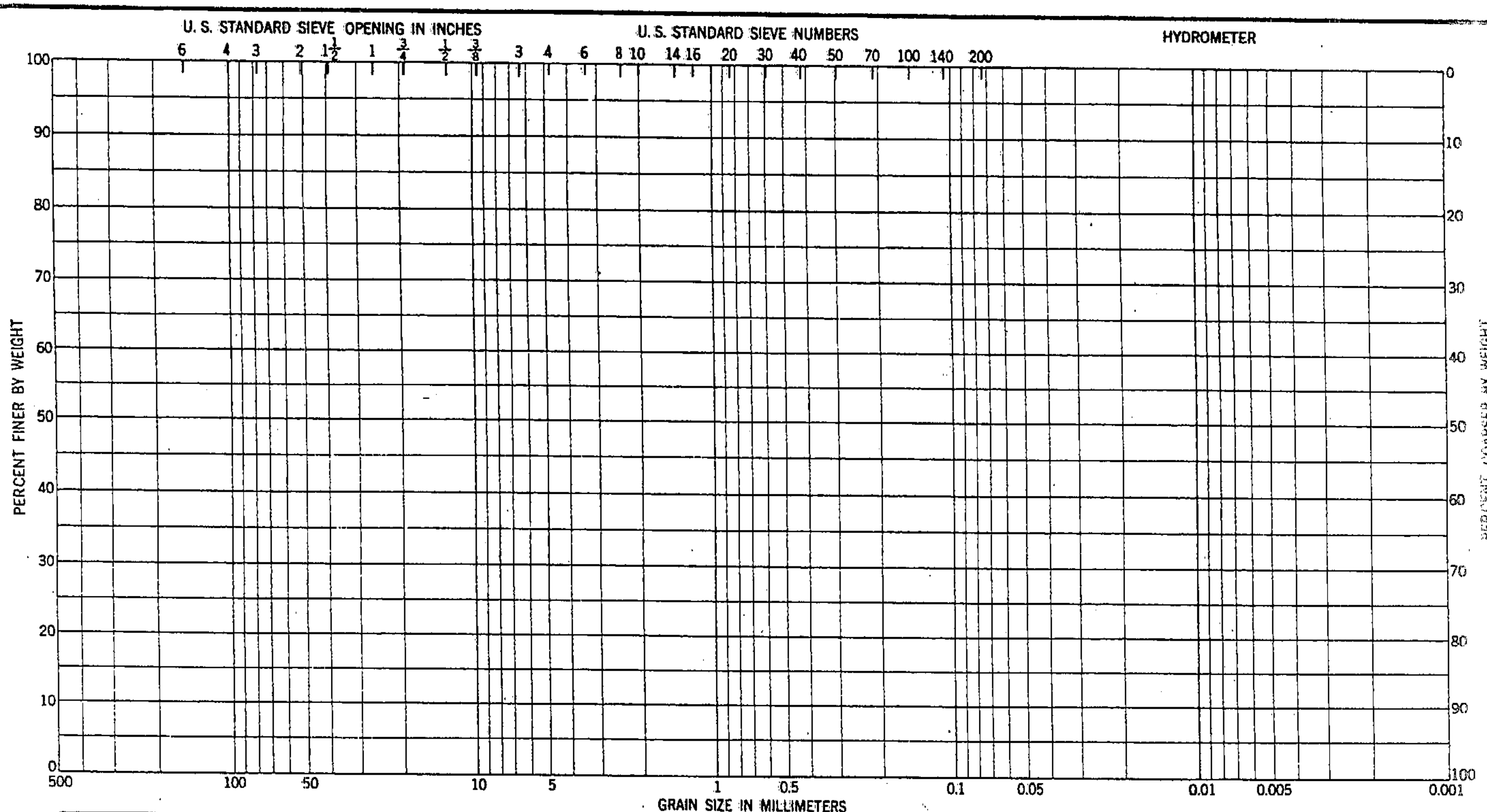

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project

Area

Boring No.

Date

GRADATION CURVES

ENG FORM MAY 63 2087

MARINE BENTHIC SURVEY AND ASSESSMENT FOR VIRGINIA KEY AND DINNER KEY MIAMI-DADE COUNTY, FLORIDA

MARINE BENTHIC SURVEY AND ASSESSMENT FOR VIRGINIA KEY AND DINNER KEY, MIAMI-DADE COUNTY, FLORIDA.

November 2001

Prepared for:
U.S. Army Corps of Engineers
Jacksonville District
400 W. Bay Street
Jacksonville, FL 32202

Prepared by:
Dial Cordy and Associates Inc.
490 Osceola Avenue
Jacksonville Beach, FL 32250

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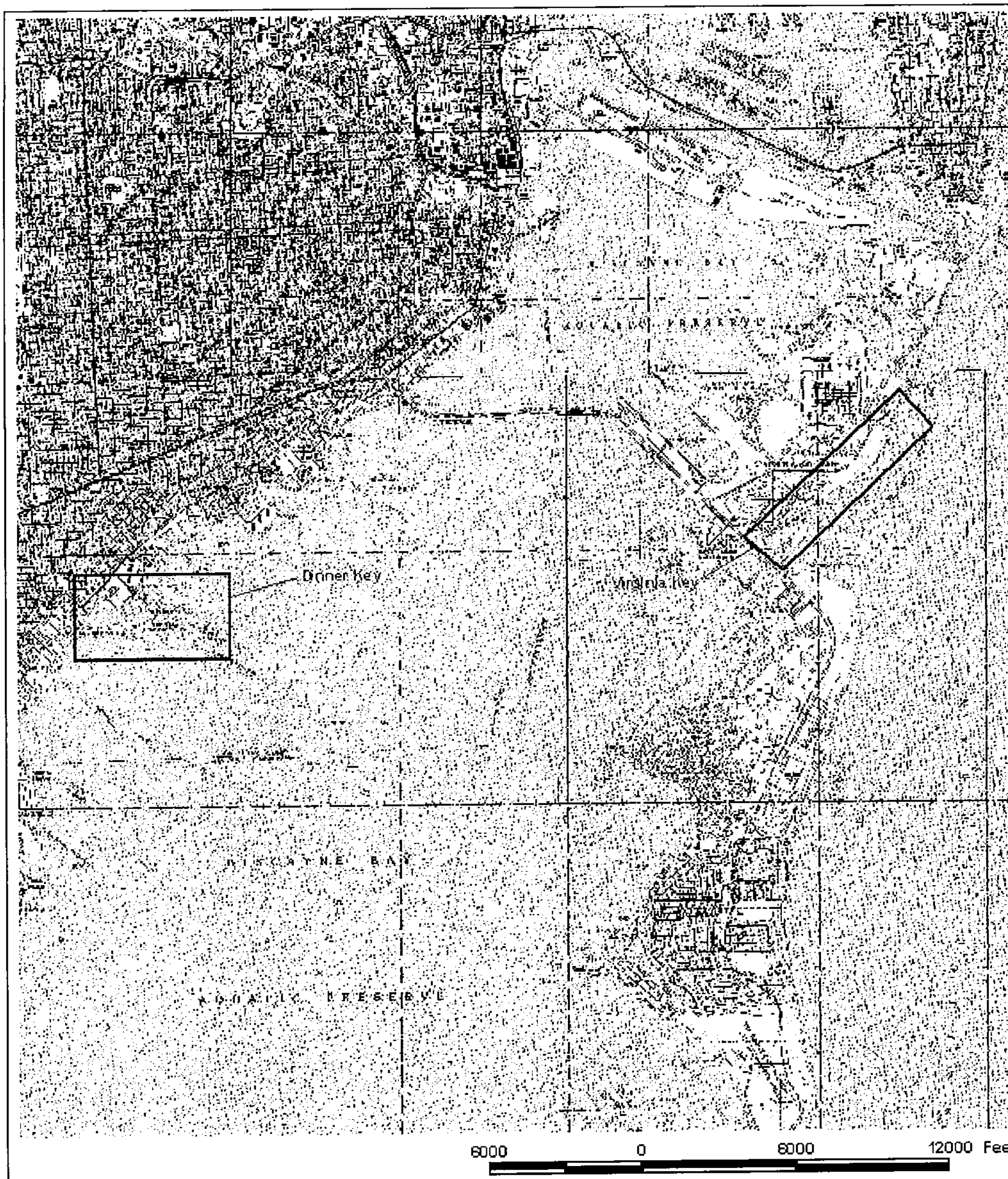
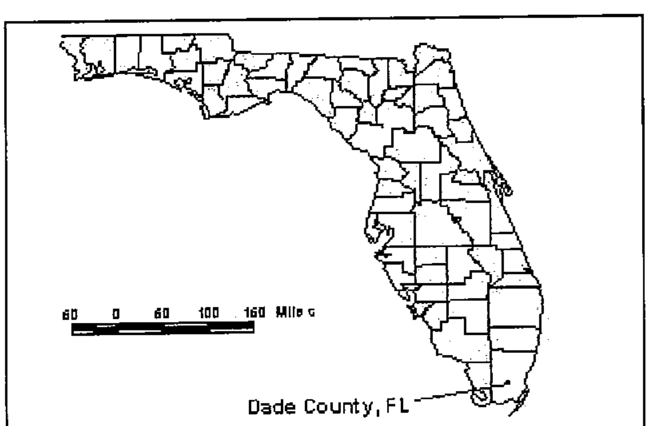
1.0 INTRODUCTION

Dial Cordy and Associates Inc. (DC&A) was contracted by the Jacksonville District Army Corps of Engineers (Corps) under contract DACW 17-99-D-0057 0022 to provide a marine benthic survey and assessment in the vicinity of Virginia Key and Dinner Key, Miami-Dade County, Florida (Figure 1).

1.1 Project Purpose

The objective of the survey is to document the presence, location, species composition, density, and extent of seagrass and other marine vegetation, and any nearshore hardbottom resources identified in the areas surrounding Dinner Key and Virginia Key. The U.S. Army Corps of Engineers (Corps) will use this information to assess potential impact to marine resources caused by proposed shoreline protection and environmental restoration efforts. In addition, this information will be incorporated by the Corps into NEPA documents and utilized as baseline biological information during the permitting process.





Location Map	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 6,000'	Drawn By: MR
Date: October, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 1

2.0 TECHNICAL APPROACH

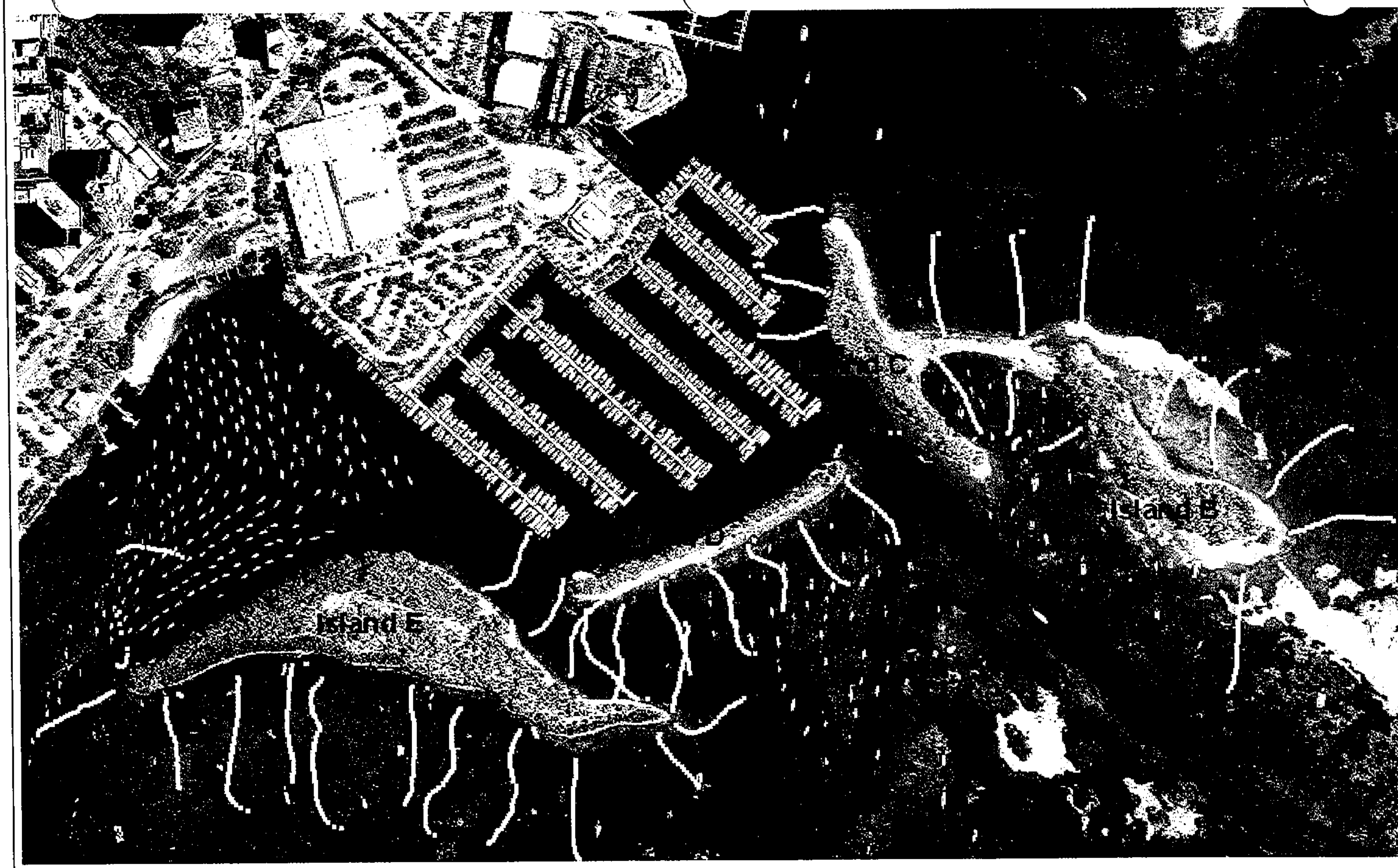
A description of the methods utilized to document the distribution, occurrence, abundance, and density of marine seagrass within the study area is described below. Although the focus of this study involved mapping marine seagrasses, occurrences of other resource types within the survey area were also recorded. The additional resource types included rocks, sand, marine algae, and mixed assemblages of types. Surveys were conducted August 21-23, 2001.

2.1 Location of Survey Transects

Survey transects were located perpendicular to the shorelines of the various islands and were 300 feet long and spaced 200 feet part. Survey transects for Dinner Key are shown in Figure 2 and those for Virginia Key are illustrated in Figure 3.

2.2 Video Survey Methodology

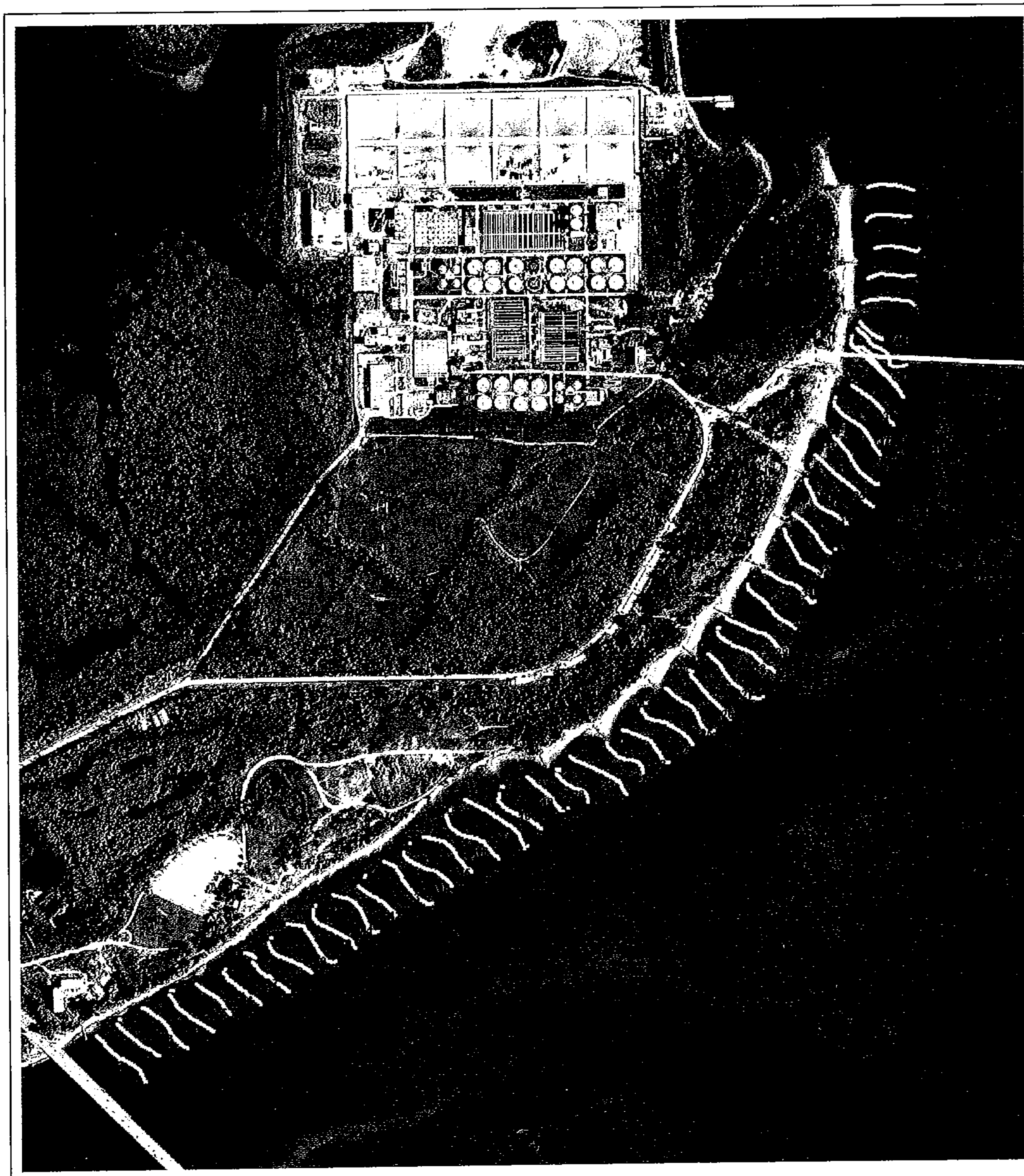
The beginnings and ends of each transect were located using a Trimble Differential Global Positioning System (DGPS). Once the beginning of each transect was located, an underwater video camera was lowered to within one-foot of the bottom and towed along the transect line using Hypack® Max software to maintain the vessel's course and also superimpose location coordinates onto the video. The underwater video camera was viewed onboard while being towed and the occurrence of seagrass, rocks, sand, algae, and assemblages of types were documented. The documentation was used later when reviewing the video to denote the resource description and DGPS location. For mapping purposes, the following resource type classification system was used:



Dinner Key - Towed Video Tracklines

500 0 500 1000 1500 2000 Feet

Dinner Key Survey Transects	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 500'	Drawn By: MR
Date: September, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 2



Virginia Key , Towed Video Trackline

750 0 750 1500 2250 Feet

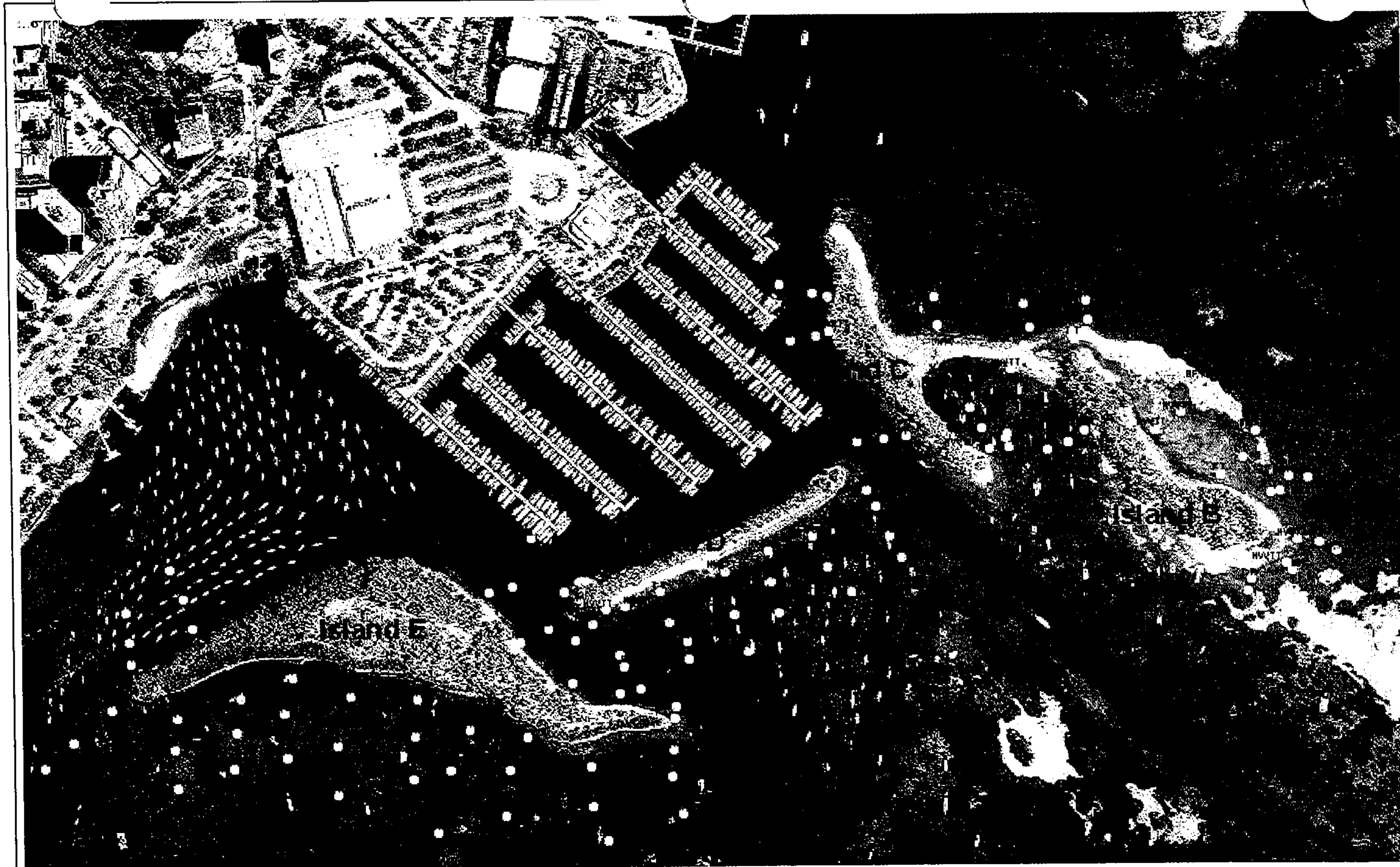
Virginia Key Survey Transects	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 750'	Drawn By: MR
Date: October, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 3

Bottom Resources	Description
Thalassia testudinum	Turtle grass was the dominant resource
Halodule wrightii	Shoal grass was the dominant resource
Mixed grasses	A mixture of *Thalassia testudinum, Syringodium filiforme,* and *Halodule wrightii* was the dominant resource
Sand	Sand was the dominant resource
Sand/Algae/ *HD*	Marine algae was the dominant resource with scattered patches of *Halophila decipiens*
Sand/Algae	Marine algae was the dominant resource
Rock/Algae	A mixture of rock and algae were the dominant resource

Following compilation of resource type distribution, a spreadsheet was developed incorporating the resource classification system. Resource types were superimposed over an aerial map using ArcView® GIS. This approach allows the resource types located within the project area to be seen.

2.3 Biological Data Collection

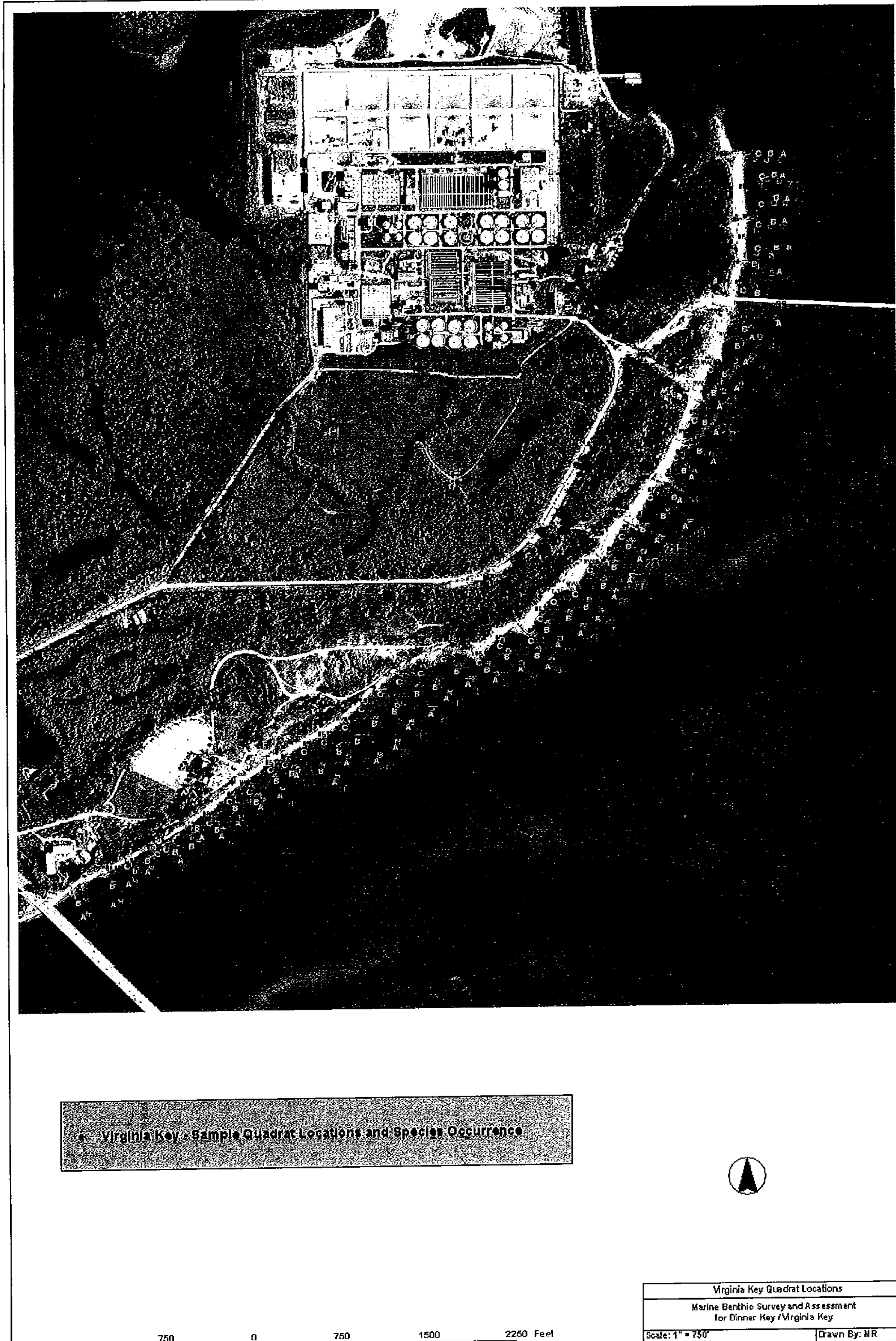
To obtain biological data regarding the location, occurrence, abundance, and density of marine seagrass, a snorkel point intercept survey was performed along every transect line. For each transect, the average percent (percent of 16, 25 x 25 cm sub-units within a 1 m^2 quadrat that contains at least one seagrass shoot) was estimated in 1 m^2 quadrats at three intervals along each transect line (Fonseca, et al., 1998; Virnstein, 1995; Braun-Blanquet, 1965). Locations of quadrat sampling for Dinner Key and Virginia Key are shown in Figure 4 and Figure 5, respectively. Specific data recorded within each 1 m^2 quadrat for each marine seagrass species present included the number of sub-units containing at least one shoot, an average cover abundance score (Braun-Blanquet, 1965), a description of the substrate type, and any other observations considered useful. Field data were entered into a spreadsheet for analysis.



Dinner Key - Sample Quadrat Location and Species Occurrence

500 0 500 1000 1500 2000 Feet

Dinner Key Quadrat Locations	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 500'	Drawn By: MR
Date: September, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 4



Virginia Key Quadrat Locations	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 750'	Drawn By: MR
Date: October, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 5

2.4 Analysis and Interpretation

Community types were classified by the dominant resource type within the area. For example, if one or two rocks were identified within an area composed predominately of *H. wrightii*, then *H. wrightii* was considered the dominant resource type. Frequency of occurrence, abundance, and density were calculated from the quadrat data based on Braun-Blanquet (1965) methodology.

3.0 RESULTS

The survey area around Dinner Key was divided into four sections, one for each of the Dinner Key islands B, C, D and E. Virginia Key was not divided into sections. The results for each survey area are divided into frequency of occurrence, abundance, and density.

3.1 Seagrass Occurrence and Distribution Patterns - Video Surveys

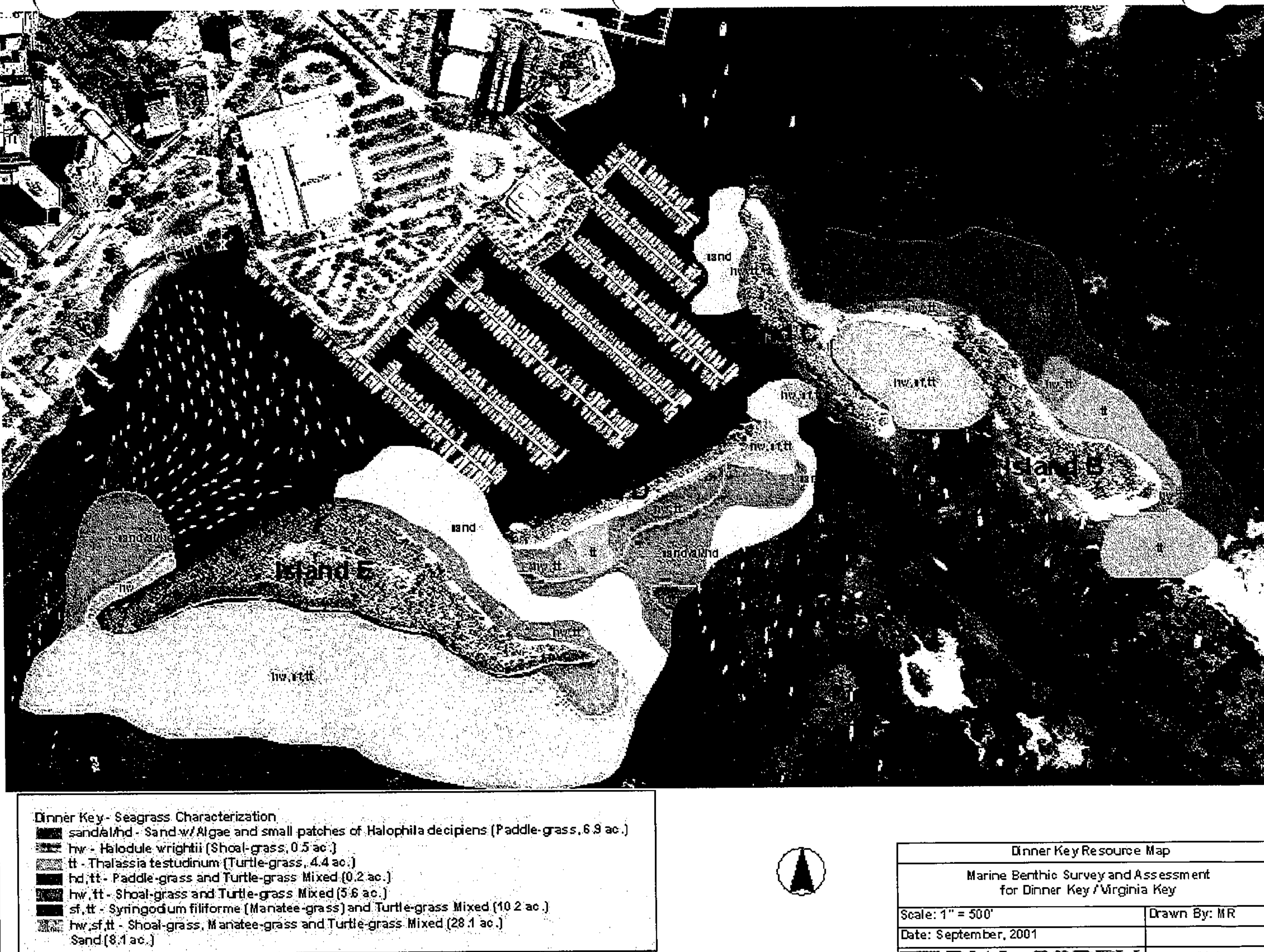
The occurrence and distribution patterns of marine seagrasses in the survey areas are described below. Four marine seagrasses were identified during the video survey. These seagrasses occurred in single and mixed species assemblages within the survey area.

3.1.1 General Occurrence Patterns

Marine seagrass species observed within the survey area include *H. wrightii, T. testudinum, S. filiforme* and *Halophila decipiens.* Although seagrasses occurred throughout most of the study area, the frequency of occurrence, abundance, and density varied. Marine seagrasses were most dense within and immediately adjacent to the existing islands. Of the four marine seagrass species observed, *T. testudinum* and *H. wrightii* were the most prevalent along the transects, while *S. filiforme* was frequently observed, but was more scattered. *H. decipiens* occurred in small patches within the mooring and marina areas near Dinner Key islands D and E.

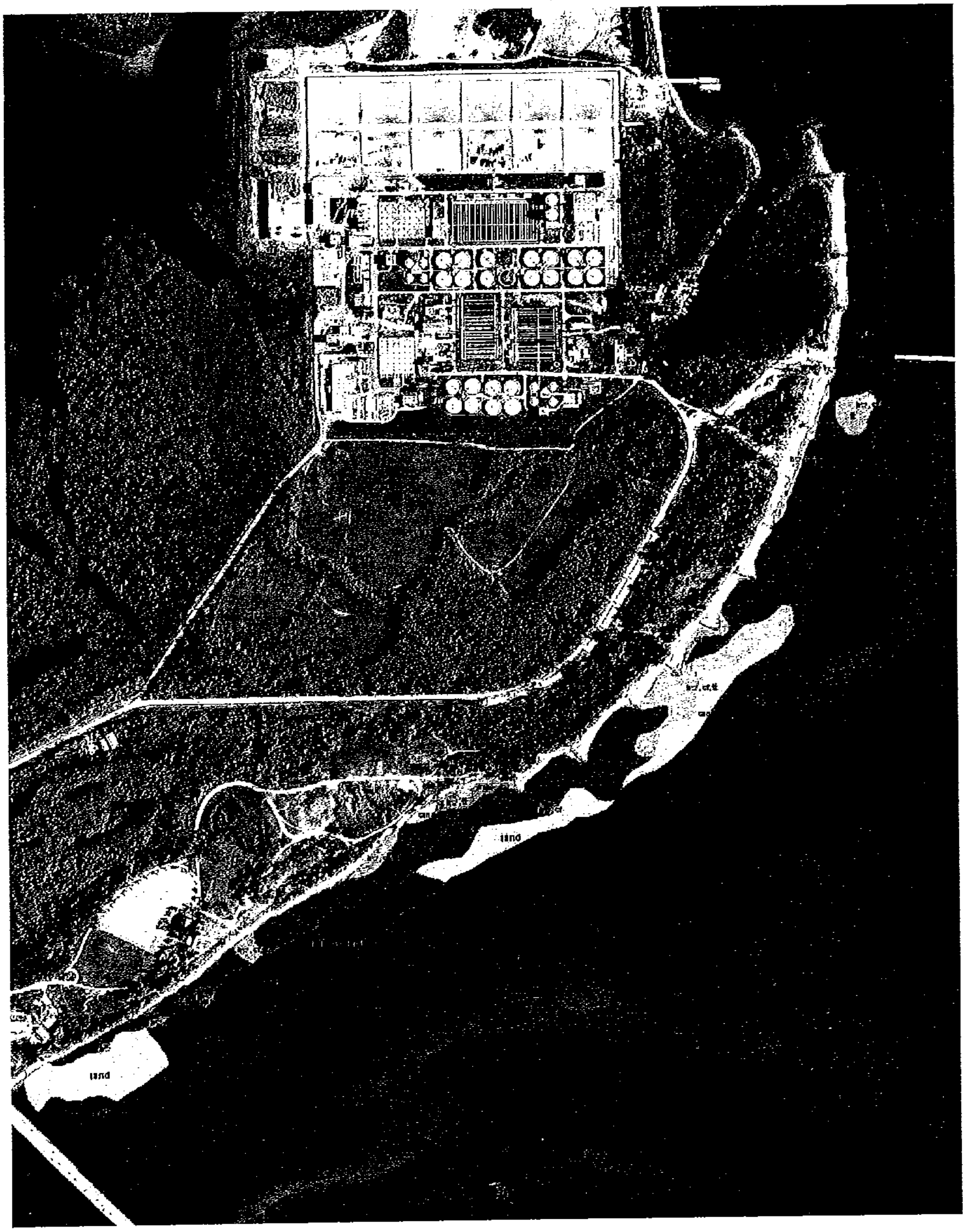
3.1.2 Seagrass Distribution

Seagrass distribution is illustrated in the natural resource maps for Dinner Key (Figure 6) and Virginia Key (Figure 7). A description of seagrass distribution by survey area is provided below.



Note: Acreage estimates indicate area of occurrence for a particular community type, not actual coverage due to variation in seagrass density.

Dinner Key Resource Map	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 500'	Drawn By: MR
Date: September, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 6



Virginia Key - Seagrass Characterization

- hw - Halodule wrightii (Shoal-grass, 0.1 ac.)
- sf - Syringodium filiforme (Manatee-grass, 0.5 ac.)
- tt - Thalassia testudinum (Turtle-grass, 1.0 ac.)
- hw, sf - Shoal-grass and Manatee-grass Mixed (0.6 ac.)
- hw, tt - Shoal-grass and Turtle-grass Mixed (0.9 ac.)
- sf, tt - Manatee-grass and Turtle-grass Mixed (48.0 ac.)
- hw, sf, tt - Shoal-grass, Manatee-grass and Turtle-grass Mixed (8.7 ac.)
- Predominantly Sand (15.2 ac.)
- Sand w/Scattered Rock and Algae (16.2 ac.)

Note: Acreage estimates indicate area of occurrence for a particular community type, not actual coverage due to variation in seagrass density.

750 0 750 1500 2250 Feet

Virginia Key Resource Map	
Marine Benthic Survey and Assessment for Dinner Key / Virginia Key	
Scale: 1" = 750'	Drawn By: MR
Date: October, 2001	
DIAL CORDY AND ASSOCIATES INC	J01-508
	Figure 7

3.1.2.1 Dinner Key

The survey area surrounding Dinner Key consisted of approximately 64 acres, of which approximately 56 acres contained marine seagrasses. Mixed assemblages of *T. testudinum, S. filiforme,* and *H. wrightii* comprised the dominant marine seagrasses and occupied approximately 49 acres. *H. decipiens*, occurred in small scattered patchy areas approximately 6.9 acres. The remaining area was comprised of mixed assemblages of sand and algae. Some areas of rock/algae were found within mooring areas and along channels. They consisted mostly of small piles of rubble with some attached algae, sponges, and fire coral. A representative list of species found is included in Appendix B. Photographs of the different habitat types are included in Appendix C.

3.1.2.2 Virginia Key

Approximately 54 of the 84 acres surveyed around Virginia Key contained seagrasses. *T. testudinum* and *S. filiforme* were the dominant seagrasses present. *H. wrightii* was also present but was widely scattered. Additionally, some small areas of algae were observed, but these areas were too small to map. These areas were primarily in the southern portion of the project area in the vicinity of the causeway bridge. The remaining area consisted mainly of sand.

3.2 Seagrass Frequency of Occurrence, Abundance, and Density - Snorkel Surveys

Frequency of occurrence, abundance, and density were calculated for each seagrass species along each island they occurred based on the Braun-Blanquet Technique (Braun-Blanquet, 1965). A summary of field data is provided in Appendix A. For each area, the values were calculated based on the total transect length.

The scale values are:

0.1	=	Solitary shoots with small cover
0.5	=	Few shoots with small cover
1.0	=	Numerous shoots but less than 5% cover
2.0	=	Any number of shoots but with 5-25% cover
3.0	=	Any number of shoots but with 25-50% cover
4.0	=	Any number of shoots but with 50-75% cover
5.0	=	Any number of shoots but with >75% cover

From the survey of quadrats along each transect, frequency of occurrence, abundance and density of seagrass was computed as follows:

Frequency of occurrence	=	Number of occupied quadrats/total number of quadrats
Abundance	=	Sum of cover scale values/number of occupied quadrats
Density	=	Sum of cover scale values/total number of quadrats

Mean values are illustrated in Table 1.

Table 1 Mean Seagrass Frequency of Occurrence, Abundance, and Density Values for Dinner and Virginia Key Survey Transects

	Species *	Frequency	Abundance	Density
Dinner Key				
Island B	TT	0.64	2.66	2.22
	SF	0.40	2.19	1.10
	HW	0.30	2.07	0.81
Island C	TT	0.05	0.30	0.10
	HW	0.17	5.00	0.83
Island D	TT	0.22	1.05	0.55
	SF	0.03	0.73	0.10
	HW	0.27	1.51	0.72
	HD	0.12	1.00	0.33
Island E	TT	0.64	3.37	2.46
	SF	0.32	1.70	0.91
	HW	0.31	1.44	0.81
	HD	0.05	1.88	0.18
Dinner Key Total	TT	0.52	2.61	1.86
	SF	0.27	1.80	0.76
	HW	0.29	1.78	0.82
	HD	0.04	1.32	0.14
Virginia Key	TT	0.36	2.48	1.53
	SF	0.36	2.31	1.46
	HW	0.11	2.17	0.47

*HW = *Halodule wrightii* SF = *Syringodium filiforme*
TT = *Thalassia testudinum* HD = *Halophila decipiens*

3.2.1 Dinner Key Survey Area

Frequency

Frequency of occurrence for marine seagrasses within the Dinner Key area was highest for *T. testudinum* at 52 percent, followed by *H. wrightii* at 29 percent and SF at 27 percent. *H. decipiens* had the lowest frequency of occurrence with a value of 4 percent, as it was found only in two areas.

Abundance

Within the Dinner Key area, abundance values were highest for *T. testudinum* at 2.61, followed by *S. filiforme* at 1.80, *H. wrightii* at 1.78 and *H. decipiens* at 1.32.

Density

Density was highest for *T. testudinum* with a value of 1.86, followed by *H. wrightii* at 0.82, *S. filiforme* at 0.76, and *H. decipiens* at 0.14.

3.2.2 Virginia Key Survey Area

Frequency

Frequency of occurrence for *T. testudinum* and *S. filiforme* was 0.36 and for *H. wrightii* it was 0.11. The marine seagrasses occurred predominately towards the northeastern portion of this survey area.

Abundance

Abundance value range for *T. testudinum* was 2.48 followed by *S. filiforme* at 2.31 and *H. wrightii* at 2.17.

Density

Within the survey area, the density of *T.* testudinum was 1.53 followed by *s. filiforme* at 1.46 and *H. wrightii* at 0.47.

4.0 SUMMARY AND CONCLUSIONS

This study was conducted to document the location, frequency of occurrence, abundance, and density of marine seagrasses within the Dinner Key and Virginia Key areas.

Marine seagrasses were distributed throughout the survey area. Within the Dinner Key area *T. testudinum* was the most abundant seagrass present. *H. wrightii* and *S. filiforme* were also common occurrences in this area. *H. decipiens* was present but found only in scattered patches within the marina and mooring areas.

T. testudinum and *S. filiforme* were the most abundant seagrasses along the Virginia Key area. *H. wrightii* also occurred in the area.

Over the entire survey area, density was relatively high for *T. testudinum* with a value of 1.86 at Dinner Key and 1.53 at Virginia Key. Average density for *H. wrightii* was 0.82 for the Dinner Key area and 0.47 for Virginia Key. Density for *H. decipiens* was negligible, since this species was observed in only two areas in the Dinner Key area and was not observed in the Virginia Key area.

Hardbottom communities were limited mainly to scattered rubble with attached sponges and algae and occurred primarily in the marina area and the southern end of Virginia Key.

5.0 LITERATURE CITED

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Virstein, R. W. 1995. Seagrass landscape diversity in the Indian River Lagoon, Florida: The importance of geographic scale and pattern. Bull. Mar. Sci. 57: 67- 74.

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November 15, 2001

APPENDIX A

Field Data

Maarine SM

u vy ofSMDSSdfvVgvKKSl sK,gsyF,sLlCSAgf c Ff lt I SLSNtt Fggfl tf CSl mSfl KsI Sv, dF gbf I fmSAvtsos,sfK

I N5MueNi	n Mur	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Island B	22-Aug-01	10 30 07	11C	TT		16	4
Island B	22-Aug-01	10 33 28	11B	T T		16	3
Island B	22-Aug-01	10 34 46	11A	T T		16	4
Island B	22-Aug-01	10 40 21	10C	T T		16	2
Island B	22-Aug-01	10 40 21	10C	HW		16	2
Island B	22-Aug-01	10 41 29	10B	T T		16	4
Island B	22-Aug-01	11 41 29	10B	SF		14	1
Island B	22-Aug-01	10 43 19	10A	T T		16	4
Island B	22-Aug-01	10 48 06	9C	T T		16	3
Island B	22-Aug-01	10 48 06	9C	HW		14	1
Island B	22-Aug-01	10 49 20	9B	T T		16	4
Island B	22-Aug-01	10 49 20	9B	SF		16	2
Island B	22-Aug-01	10 50 47	9A	T T		16	3
Island B	22-Aug-01	10 50 47	9A	SF		12	2
Island B	22-Aug-01	10 55 25	8C	T T		16	3
Island B	22-Aug-01	10 55 25	8C	HW		4	R
Island B	22-Aug-01	10 56 14	8B	T T		14	3
Island B	22-Aug-01	10 56 14	8B	SF		10	1
Island B	22-Aug-01	10 57 26	8A	T T		16	4
Island B	22-Aug-01	10 57 26	8A	SF		12	2
Island B	22-Aug-01	11 06 22	7C	T T		16	4
Island B	22-Aug-01	11 09 40	7B	T T		16	5
Island B	22-Aug-01	11 10 58	7A	T T		16	4
Island B	22-Aug-01	11 10 58	7A	SF		8	1
Island B	22-Aug-01	11 17 08	6C	T T		11	3
Island B	22-Aug-01	11 17 08	6C	HW		16	2
Island B	22-Aug-01	11 19 19	6B	T T		16	2
Island B	22-Aug-01	11 19 19	6B	HW		7	1
Island B	22-Aug-01	11 20 54	6A	T T		2	R
Island B	22-Aug-01	11 20 54	6A	SF		3	1
Island B	22-Aug-01	11 32 22	5C	T T		16	5
Island B	22-Aug-01	11 41 06	5B	T T		16	5
Island B	22-Aug-01	11 41 06	5B	SF		8	0.5
Island B	22-Aug-01	11 43 02	5A	SF		12	1
Island B	22-Aug-01	11 43 02	5A	T T		6	2
Island B	22-Aug-01	11 47 54	4C	T T		10	2
Island B	22-Aug-01	11 47 54	4C	HW		14	2
Island B	22-Aug-01	11 49 13	4B	SF		15	4
Island B	22-Aug-01	11 50 54	4A	T T		16	3
Island B	22-Aug-01	11 50 54	4A	SF		16	3
Island B	22-Aug-01	11 55 53	3C	HW		12	2
Island B	22-Aug-01	11 58 43	3B	SF		16	4

I N5MueNi	n Mır	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Island B	22-Aug-01	11 58 43	3B	T T		4	0.5
Island B	22-Aug-01	12 00 20	3A	SF		16	4
Island B	22-Aug-01	12 00 20	3A	T T		3	0.5
Island B	22-Aug-01	12 05 32	14A	HW		8	2
Island B	22-Aug-01	12 05 32	14A	SF		16	4
Island B	22-Aug-01	12 05 32	14A	T T		5	0.5
Island B	22-Aug-01	12 08 16	14B	HW		16	4
Island B	22-Aug-01	12 08 16	14B	T T		4	1
Island B	22-Aug-01	12 09 33	14C	SF		12	2
Island B	22-Aug-01	12 12 05	13C	HW		16	4
Island B	22-Aug-01	12 12 05	13C	T T		12	1
Island B	22-Aug-01	12 15 40	13A	SF		15	3
Island B	22-Aug-01	12 15 40	13A	T T		6	R
Island B	22-Aug-01	12 17 19	13B	HW		8	2
Island B	22-Aug-01	12 17 19	13B	SF		14	2
Island B	22-Aug-01	12 17 19	13B	T T		2	R
Island B	22-Aug-01	12 20 52	12C	HW		12	3
Island B	22-Aug-01	12 22 57	12B	HW		16	3
Island B	22-Aug-01	12 22 57	12B	SF		6	1
Island B	22-Aug-01	12 24 02	12A	HW		16	4
Island B	22-Aug-01	12 24 02	12A	SF		8	1
Island B	22-Aug-01	12 24 02	12A	T T		2	R
Island C	22-Aug-01	12 38 07	2A				
Island C	22-Aug-01	12 38 42	2B				
Island C	22-Aug-01	12 39 12	2C	T T		3	0.5
Island C	22-Aug-01	12 40 45	1C	HW		16	5
Island C	22-Aug-01	12 40 45	1C	T T		2	R
Island C	22-Aug-01	12 41 38	1B				
Island C	22-Aug-01	12 42 04	1A				
Island D	22-Aug-01	12 47 53	15A				
Island D	22-Aug-01	12 48 28	15B	HW		6	1
Island D	22-Aug-01	12 48 28	15C	T T		3	0.5
Island D	22-Aug-01	12 48 28	15C	SF		8	2
Island E	22-Aug-01	13 22 48	25A				
Island E	22-Aug-01	13 23 49	25B				
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Island E	22-Aug-01	13 24 20	25C	HW		2	R
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Island E	22-Aug-01	13 29 47	23A	T T		10	2
Island E	22-Aug-01	13 30 45	23B				
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Island E	22-Aug-01	13 31 35	23C	HW		6	1
Island E	22-Aug-01	13 32 59	22C	SF		2	R
Island E	22-Aug-01	13 33 37	22B				R
Island E	22-Aug-01	13 34 50	22A	T T		16	4
Island E	22-Aug-01	13 34 50	22A	HW		12	2

I N5MueNi	n Mır	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Island E	22-Aug-01	13 36 37	26A				
Island E	22-Aug-01	13 37 47	26B				
Island E	22-Aug-01	13 38 09	26C	T T		8	2
Island D	23-Aug-01	08 50 32	16C	SF		1	R
Island D	23-Aug-01	08 54 03	16B	SF		1	R
Island D	23-Aug-01	08 54 03	16B	T T		6	0.5
Island D	23-Aug-01	08 54 03	16B	HW		16	3
Island D	23-Aug-01	08 55 24	16A	HD		12	2
Island D	23-Aug-01	09 01 22	17C	HD		6	1
Island D	23-Aug-01	09 03 08	18C	T T		12	2
Island D	23-Aug-01	09 03 08	18C	HW		10	1
Island D	23-Aug-01	09 04 48	18C	HD		3	0.5
Island D	23-Aug-01	09 06 03	18B	HD		3	0.5
Island D	23-Aug-01	09 07 39	19A	T T		3	0.5
Island D	23-Aug-01	09 07 39	19A	HD		4	0.5
Island D	23-Aug-01	09 08 57	19B	HD		8	2
Island D	23-Aug-01	09 10 09	19C	T T		2	R
Island D	23-Aug-01	09 10 09	19C	HW		8	2
Island D	23-Aug-01	09 12 06	20C	T T		5	0.5
Island D	23-Aug-01	09 13 27	20B	T T		4	0.5
Island D	23-Aug-01	09 14 36	20A				
Island D	23-Aug-01	09 16 26	21A	HW		8	1
Island D	23-Aug-01	09 17 39	21B	HD		5	0.5
Island D	23-Aug-01	09 18 57	21C	T T		5	1
Island D	23-Aug-01	09 18 57	21C	HW		16	3
Island E	23-Aug-01	09 24 22	27A	T T		12	3
Island E	23-Aug-01	09 24 22	27A	HW		10	2
Island E	23-Aug-01	09 26 01	27B	T T		16	3
Island E	23-Aug-01	09 26 01	27B	HW		16	2
Island E	23-Aug-01	09 27 08	27A	SF		2	R
Island E	23-Aug-01	09 27 08	27A	T T		10	1
Island E	23-Aug-01	09 27 08	27A	HW		12	2
Island E	23-Aug-01	09 29 04	28A	SF		16	2
Island E	23-Aug-01	09 29 04	28A	T T		12	1
Island E	23-Aug-01	09 29 04	28A	HW		5	0.5
Island E	23-Aug-01	09 30 39	28B	T T		16	3
Island E	23-Aug-01	09 30 39	28B	HW		16	1
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Island E	23-Aug-01	09 31 52	28C	HW		6	1
Island E	23-Aug-01	09 35 38	29B	SF		16	2
Island E	23-Aug-01	09 35 38	29B	T T		16	2
Island E	23-Aug-01	09 36 49	29A	SF		12	2
Island E	23-Aug-01	09 36 49	29A	T T		16	4
Island E	23-Aug-01	09 36 49	29A	HW		4	1
Island E	23-Aug-01	09 38 36	30A	SF		14	2
Island E	23-Aug-01	09 38 36	30A	T T		12	2
Island E	23-Aug-01	09 38 36	30A	HW		8	1
Island E	23-Aug-01	09 40 39	30B	SF		16	3

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Island E	23-Aug-01	09 40 39	30B	HW		8	1
Island E	23-Aug-01	09 41 42	30C	SF		16	4
Island E	23-Aug-01	09 41 42	30C	T T		8	2
Island E	23-Aug-01	09 44 32	31C	SF		16	4
Island E	23-Aug-01	09 44 32	31C	T T		12	2
Island E	23-Aug-01	09 44 32	31C	HW		5	2
Island E	23-Aug-01	09 46 05	31B	SF		4	0.5
Island E	23-Aug-01	09 46 05	31B	T T		16	5
Island E	23-Aug-01	09 47 28	31A	SF		16	4
Island E	23-Aug-01	09 47 28	31A	T T		14	2
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Island E	23-Aug-01	09 49 49	32A	SF		12	3
Island E	23-Aug-01	09 49 49	32A	T T		16	4
Island E	23-Aug-01	09 51 24	32B	SF		10	1
Island E	23-Aug-01	09 51 24	32B	T T		16	5
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Island E	23-Aug-01	09 53 00	32C	T T		16	5
Island E	23-Aug-01	09 53 00	32C	HW		6	1
Island E	23-Aug-01	09 55 04	33C	SF		10	2
Island E	23-Aug-01	09 55 04	33C	T T		16	4
Island E	23-Aug-01	09 55 04	33C	HW		3	0.5
Island E	23-Aug-01	09 56 38	33B	T T		16	5
Island E	23-Aug-01	09 56 38	33B	HW		9	1
Island E	23-Aug-01	09 58 05	33A	SF		2	1
Island E	23-Aug-01	09 58 05	33A	T T		16	5
Island E	23-Aug-01	09 59 53	34A	SF		2	R
Island E	23-Aug-01	09 59 53	34A	T T		16	5
Island E	23-Aug-01	09 59 53	34A	HW		7	1
Island E	23-Aug-01	10 01 10	34B	SF		6	1
Island E	23-Aug-01	10 01 10	34B	T T		16	5
Island E	23-Aug-01	10 02 38	34C	SF		3	0.5
Island E	23-Aug-01	10 02 38	34C	T T		16	4
Island E	23-Aug-01	10 02 38	34C	HW		1	R
Island E	23-Aug-01	10 06 17	35C	T T		16	5
Island E	23-Aug-01	10 06 17	35C	HW		9	2
Island E	23-Aug-01	10 07 29	35B	T T		16	5
Island E	23-Aug-01	10 07 29	35B	HW		7	1
Island E	23-Aug-01	10 09 03	35A	T T		16	5
Island E	23-Aug-01	10 11 44	36A	SF		4	1
Island E	23-Aug-01	10 11 44	36A	T T		10	2
Island E	23-Aug-01	10 11 44	36A	HW		15	2
Island E	23-Aug-01	10 13 14	36B	SF		2	R
Island E	23-Aug-01	10 13 14	36B	T T		10	2
Island E	23-Aug-01	10 13 14	36B	HW		14	2
Island E	23-Aug-01	10 15 01	36C	SF		6	1
Island E	23-Aug-01	10 15 01	36C	T T		5	1
Island E	23-Aug-01	10 15 01	36C	HW		15	4
Island E	23-Aug-01	10 16 57	37C	HW		2	R

1 N5MueNi	n Mir	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Island E	23-Aug-01	10 18 25	37B	HD		8	2
Island E	23-Aug-01	10 19 35	37A	HD		2	0.5
Island E	23-Aug-01	10 21 32	38A	HD		14	3
Island E	23-Aug-01	10 24 08	38B	HD		9	2
Island E	23-Aug-01	10 25 09	38C	HW		11	2
Virginia Key	23-Aug-01	10 53 15	1C				
Virginia Key	23-Aug-01	10 54 27	1B				
Virginia Key	23-Aug-01	10 55 17	1A				
Virginia Key	23-Aug-01	10 57 45	2A				
Virginia Key	23-Aug-01	10 59 15	2B				
Virginia Key	23-Aug-01	11 00 09	2C	SF		16	4
Virginia Key	23-Aug-01	11 00 09	2C	T T		5	2
Virginia Key	23-Aug-01	11 01 41	3C	T T		8	3
Virginia Key	23-Aug-01	11 02 36	3B	HW		3	1
Virginia Key	23-Aug-01	11 03 18	3A				
Virginia Key	23-Aug-01	11 05 07	4C				
Virginia Key	23-Aug-01	11 06 05	4B				
Virginia Key	23-Aug-01	11 06 44	4A	T T		14	3
Virginia Key	23-Aug-01	11 06 44	4A	SF		12	2
Virginia Key	23-Aug-01	11 08 02	5C	SF		16	3
Virginia Key	23-Aug-01	11 08 02	5C	T T		9	2
Virginia Key	23-Aug-01	11 09 08	5B	T T		4	1
Virginia Key	23-Aug-01	11 09 08	5B	HW		9	3
Virginia Key	23-Aug-01	11 10 40	5A				
Virginia Key	23-Aug-01	11 12 42	6A				
Virginia Key	23-Aug-01	11 13 46	6B1	SF		6	2
Virginia Key	23-Aug-01	11 13 46	6B1	T T		15	4
Virginia Key	23-Aug-01	11 24 34	6B2	T T		7	2
Virginia Key	23-Aug-01	11 24 34	6B2	SF		13	4
Virginia Key	23-Aug-01	11 25 43	6C	T T		12	3
Virginia Key	23-Aug-01	11 25 43	6C	SF		10	2
Virginia Key	23-Aug-01	11 27 16	7C	SF		16	4
Virginia Key	23-Aug-01	11 27 16	7C	T T		4	1
Virginia Key	23-Aug-01	11 28 23	7B	SF		8	3
Virginia Key	23-Aug-01	11 28 23	7B	HW		8	2
Virginia Key	23-Aug-01	11 29 28	7A	HW		4	0.5
Virginia Key	23-Aug-01	11 32 01	8A				
Virginia Key	23-Aug-01	11 33 02	8B	SF		16	3
Virginia Key	23-Aug-01	11 33 02	8B	T T		5	0.5
Virginia Key	23-Aug-01	11 33 52	8C	SF		16	5
Virginia Key	23-Aug-01	11 33 52	8C	T T		8	3
Virginia Key	23-Aug-01	11 35 19	9C	T T		10	3
Virginia Key	23-Aug-01	11 35 19	9C	SF		5	1
Virginia Key	23-Aug-01	11 35 19	9C	HW		10	3
Virginia Key	23-Aug-01	11 37 08	9B	HW		4	0.5
Virginia Key	23-Aug-01	11 38 03	9A				
Virginia Key	23-Aug-01	11 40 51	10A				
Virginia Key	23-Aug-01	11 42 11	10B	T T		7	2
Virginia Key	23-Aug-01	11 42 11	10B	SF		5	1

I N5MueNi	n Mır	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Virginia Key	23-Aug-01	11 43 22	10C	SF		11	3
Virginia Key	23-Aug-01	11 43 22	10C	T T		2	0.5
Virginia Key	23-Aug-01	11 44 40	11C	SF		12	4
Virginia Key	23-Aug-01	11 44 40	11C	T T		5	1
Virginia Key	23-Aug-01	11 45 48	11B	T T		10	3
Virginia Key	23-Aug-01	11 45 48	11B	SF		10	3
Virginia Key	23-Aug-01	11 47 11	11A	T T		14	4
Virginia Key	23-Aug-01	11 47 11	11A	SF		5	2
Virginia Key	23-Aug-01	11 48 54	12C	SF		16	5
Virginia Key	23-Aug-01	11 49 50	13C	SF		16	4
Virginia Key	23-Aug-01	11 49 50	13C	T T		10	3
Virginia Key	23-Aug-01	11 51 04	14C	SF		14	3
Virginia Key	23-Aug-01	11 51 04	14C	T T		5	1
Virginia Key	23-Aug-01	11 51 04	14C	HW		3	1
Virginia Key	23-Aug-01	11 52 15	15C	SF		10	3
Virginia Key	23-Aug-01	11 52 15	15C	T T		8	2
Virginia Key	23-Aug-01	11 52 15	15C	HW		14	3
Virginia Key	23-Aug-01	11 54 51	16C	SF		8	2
Virginia Key	23-Aug-01	11 55 49	17C				
Virginia Key	23-Aug-01	11 57 02	18C	T T		14	4
Virginia Key	23-Aug-01	11 57 02	18C	HW		8	3
Virginia Key	23-Aug-01	11 58 26	19C	HW		16	5
Virginia Key	23-Aug-01	12 00 25	20C	SF		10	2
Virginia Key	23-Aug-01	12 00 25	20C	T T		5	1
Virginia Key	23-Aug-01	12 01 44	21C	T T		12	3
Virginia Key	23-Aug-01	12 01 44	21C	SF		2	0.5
Virginia Key	23-Aug-01	12 03 36	22C	SF		6	1
Virginia Key	23-Aug-01	12 03 36	22C	T T		1	0.5
Virginia Key	23-Aug-01	12 04 53	23C	T T		8	3
Virginia Key	23-Aug-01	12 04 53	23C	SF		8	3
Virginia Key	23-Aug-01	12 05 55	23C	T T		16	5
Virginia Key	23-Aug-01	12 07 21	25C	T T		10	3
Virginia Key	23-Aug-01	12 07 21	25C	SF		4	1
Virginia Key	23-Aug-01	12 07 21	25C	HW		3	0.5
Virginia Key	23-Aug-01	12 08 52	26C	HW		12	4
Virginia Key	23-Aug-01	12 08 52	26C	SF		6	2
Virginia Key	23-Aug-01	12 10 30	27C	SF		8	2
Virginia Key	23-Aug-01	12 11 40	28C	SF		14	4
Virginia Key	23-Aug-01	12 13 12	29C				
Virginia Key	23-Aug-01	12 14 06	30C	T T		8	2
Virginia Key	23-Aug-01	12 14 06	30C	SF		5	1
Virginia Key	23-Aug-01	12 15 41	31C				
Virginia Key	23-Aug-01	12 16 37	32C	T T		14	2
Virginia Key	23-Aug-01	12 16 37	32C	SF		2	0.5
Virginia Key	23-Aug-01	12 18 36	33C	HW		5	1
Virginia Key	23-Aug-01	12 18 36	33C	T T		2	0.5
Virginia Key	23-Aug-01	12 21 51	34C	T T		12	3
Virginia Key	23-Aug-01	12 21 51	34C	SF		8	2
Virginia Key	23-Aug-01	12 22 38	34B	SF		14	4

1 N5MueNi	n Mur	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Virginia Key	23-Aug-01	12 22 38	34B	T T		5	1
Virginia Key	23-Aug-01	12 24 07	35C	HW		10	3
Virginia Key	23-Aug-01	12 24 07	35C	SF		5	1
Virginia Key	23-Aug-01	12 24 07	35C	T T		2	0.5
Virginia Key	23-Aug-01	12 25 17	35B	T T		12	4
Virginia Key	23-Aug-01	12 25 17	35B	SF		8	2
Virginia Key	23-Aug-01	12 26 30	36B	SF		16	5
Virginia Key	23-Aug-01	12 27 50	36C	HW		5	1
Virginia Key	23-Aug-01	12 27 50	36C	T T		6	1
Virginia Key	23-Aug-01	12 27 50	36C	SF		8	3
Virginia Key	23-Aug-01	12 30 15	37C	HW		14	4
Virginia Key	23-Aug-01	12 30 15	37C	SF		5	1
Virginia Key	23-Aug-01	12 31 47	37B	T T		15	4
Virginia Key	23-Aug-01	12 32 57	38B	T T		14	4
Virginia Key	23-Aug-01	12 32 57	38B	SF		2	0.5
Virginia Key	23-Aug-01	12 34 23	38C	T T		14	4
Virginia Key	23-Aug-01	12 34 23	38C	SF		4	1
Virginia Key	23-Aug-01	12 36 10	39C	T T		12	3
Virginia Key	23-Aug-01	12 36 10	39C	SF		6	1
Virginia Key	23-Aug-01	12 37 33	39B	T T		14	4
Virginia Key	23-Aug-01	12 39 09	40C	T T		16	4
Virginia Key	23-Aug-01	12 39 09	40C	SF		2	0.5
Virginia Key	23-Aug-01	12 39 51	40B	T T		10	3
Virginia Key	23-Aug-01	12 39 51	40B	SF		5	1
Virginia Key	23-Aug-01	12 41 07	40A	T T		10	3
Virginia Key	23-Aug-01	12 41 07	40A	SF		10	2
Virginia Key	23-Aug-01	13 31 20	39A	T T		10	3
Virginia Key	23-Aug-01	13 31 20	39A	SF		10	3
Virginia Key	23-Aug-01	13 32 49	38A	HW		5	1
Virginia Key	23-Aug-01	13 32 49	38A	T T		8	2
Virginia Key	23-Aug-01	13 32 49	38A	SF		11	3
Virginia Key	23-Aug-01	13 34 18	37A	T T		12	4
Virginia Key	23-Aug-01	13 35 23	36A	T T		12	4
Virginia Key	23-Aug-01	13 35 23	36A	SF		4	1
Virginia Key	23-Aug-01	13 36 32	35A	T T		13	4
Virginia Key	23-Aug-01	13 36 32	35A	SF		8	2
Virginia Key	23-Aug-01	13 38 15	34A	T T		15	5
Virginia Key	23-Aug-01	13 39 11	33A	T T		10	3
Virginia Key	23-Aug-01	13 39 11	33A	SF		8	2
Virginia Key	23-Aug-01	13 40 27	33B	T T		11	3
Virginia Key	23-Aug-01	13 40 27	33B	SF		10	3
Virginia Key	23-Aug-01	13 42 21	32A	T T		8	2
Virginia Key	23-Aug-01	13 42 21	32A	SF		5	1
Virginia Key	23-Aug-01	13 43 38	32B	HW		10	2
Virginia Key	23-Aug-01	13 43 38	32B	SF		8	1
Virginia Key	23-Aug-01	13 44 59	31A	T T		10	2
Virginia Key	23-Aug-01	13 44 59	31A	SF		6	1
Virginia Key	23-Aug-01	13 46 43	31B	SF		12	3
Virginia Key	23-Aug-01	13 46 43	31B	T T		7	1

1N5MueNi	n Mır	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Virginia Key	23-Aug-01	13 47 57	30B	T T		13	4
Virginia Key	23-Aug-01	13 47 57	30B	SF		6	1
Virginia Key	23-Aug-01	13 49 25	29B	SF		10	2
Virginia Key	23-Aug-01	13 50 26	28B	T T		6	1
Virginia Key	23-Aug-01	13 50 26	28B	SF		1	0.5
Virginia Key	23-Aug-01	13 51 35	27B	T T		12	4
Virginia Key	23-Aug-01	13 51 35	27B	SF		4	1
Virginia Key	23-Aug-01	13 51 35	27B	HW		5	1
Virginia Key	23-Aug-01	13 52 35	26B	T T		16	5
Virginia Key	23-Aug-01	13 52 35	26B	SF		3	1
Virginia Key	23-Aug-01	13 54 19	25B	SF		12	3
Virginia Key	23-Aug-01	13 54 19	25B	T T		6	1
Virginia Key	23-Aug-01	13 55 49	24B	SF		14	5
Virginia Key	23-Aug-01	13 55 49	24B	T T		6	1
Virginia Key	23-Aug-01	13 56 49	23B	SF		11	3
Virginia Key	23-Aug-01	13 56 49	23B	T T		5	1
Virginia Key	23-Aug-01	13 58 36	22B	T T		10	3
Virginia Key	23-Aug-01	13 58 36	22B	SF		7	2
Virginia Key	23-Aug-01	14 01 27	21B				
Virginia Key	23-Aug-01	14 02 20	20A	HW		8	2
Virginia Key	23-Aug-01	14 02 20	20A	SF		8	1
Virginia Key	23-Aug-01	14 03 23	19A	SF		14	4
Virginia Key	23-Aug-01	14 03 23	19A	T T		3	1
Virginia Key	23-Aug-01	14 04 24	18A				
Virginia Key	23-Aug-01	14 05 08	17A	HW		8	2
Virginia Key	23-Aug-01	14 06 08	16A				
Virginia Key	23-Aug-01	14 07 02	15A				
Virginia Key	23-Aug-01	14 07 56	14A				
Virginia Key	23-Aug-01	14 08 54	13A				
Virginia Key	23-Aug-01	14 09 50	12B				
Virginia Key	23-Aug-01	14 15 54	30A	HW		14	5
Virginia Key	23-Aug-01	14 18 10	29A	HW		10	3
Virginia Key	23-Aug-01	14 18 10	29A	SF		5	1
Virginia Key	23-Aug-01	14 19 21	28A	HW		10	2
Virginia Key	23-Aug-01	14 19 21	28A	SF		4	1
Virginia Key	23-Aug-01	14 20 30	27A				
Virginia Key	23-Aug-01	14 21 22	26A	T T		7	1
Virginia Key	23-Aug-01	14 21 22	26A	SF		4	0.05
Virginia Key	23-Aug-01	14 21 22	26A	HW		10	2
Virginia Key	23-Aug-01	14 22 51	25A				
Virginia Key	23-Aug-01	14 23 48	24A	HW		4	1
Virginia Key	23-Aug-01	14 24 38	23A	SF		5	1
Virginia Key	23-Aug-01	14 26 08	22A	T T		8	2
Virginia Key	23-Aug-01	14 28 10	21B	T T		10	2
Virginia Key	23-Aug-01	14 28 10	21B	SF		10	2
Virginia Key	23-Aug-01	14 29 07	20B	SF		12	3
Virginia Key	23-Aug-01	14 29 07	20B	T T		10	2
Virginia Key	23-Aug-01	14 30 05	19B	T T		12	3
Virginia Key	23-Aug-01	14 31 07	18B	SF		16	5

I N5MueNi	n Mır	u2Mid r5u	03M n2M u	da a	A2r 03ri	5q w	5Nhr 2 Mp 3inM i 5r hM13 rS9
Virginia Key	23-Aug-01	14 31 07	18B	T T		6	1
Virginia Key	23-Aug-01	14 33 08	17B	SF		12	2
Virginia Key	23-Aug-01	14 33 08	17B	T T		12	3
Virginia Key	23-Aug-01	14 34 21	16B	T T		11	3
Virginia Key	23-Aug-01	14 34 21	16B	SF		7	1
Virginia Key	23-Aug-01	14 35 25	15B	SF		14	5
Virginia Key	23-Aug-01	14 35 25	15B	T T		3	1
Virginia Key	23-Aug-01	14 36 23	14B	SF		10	3
Virginia Key	23-Aug-01	14 36 23	14B	T T		10	3
Virginia Key	23-Aug-01	14 37 37	13B	SF		12	4
Virginia Key	23-Aug-01	14 37 37	13B	T T		8	2
Virginia Key	23-Aug-01	14 39 12	12A				
Virginia Key	25-Oct-01	17 04 45	41C	T T		16	4
Virginia Key	25-Oct-01	17 03 06	41B	T T		15	2
Virginia Key	25-Oct-01	17 03 06	41B	SF		3	+
Virginia Key	25-Oct-01	17 03 06	41B	HW		2	+
Virginia Key	25-Oct-01	17 01 38	41A	T T		11	2
Virginia Key	25-Oct-01	17 01 38	41A	SF		4	+
Virginia Key	25-Oct-01	16 56 29	42C	T T		10	2
Virginia Key	25-Oct-01	16 56 29	42C	SF		16	3
Virginia Key	25-Oct-01	16 57 48	42B	SF		16	3
Virginia Key	25-Oct-01	16 57 48	42B	T T	S		1
Virginia Key	25-Oct-01	16 59 23	42A	SF		16	3
Virginia Key	25-Oct-01	16 59 23	42A	T T		7	1
Virginia Key	25-Oct-01	16 54 45	43C	T T		16	2
Virginia Key	25-Oct-01	16 54 45	43C	SF		2	R
Virginia Key	25-Oct-01	16 53 06	43B	SF		16	2
Virginia Key	25-Oct-01	16 51 09	43A	T T		10	1
Virginia Key	25-Oct-01	16 51 09	43A	SF		7	1
Virginia Key	25-Oct-01	16 51 09	43A	HW		3	R
Virginia Key	25-Oct-01	16 46 14	44C	SF		16	2
Virginia Key	25-Oct-01	16 46 14	44C	T T		12	2
Virginia Key	25-Oct-01	16 47 28	44B	T T		10	2
Virginia Key	25-Oct-01	16 47 28	44B	SF		8	1
Virginia Key	25-Oct-01	16 48 52	44A	SF		12	1
Virginia Key	25-Oct-01	16 48 52	44A	T T		11	2
Virginia Key	25-Oct-01	16 38 25	45C	HW		16	3
Virginia Key	25-Oct-01	16 41 17	45B	SF		6	1
Virginia Key	25-Oct-01	16 41 17	45B	T T		10	2
Virginia Key	25-Oct-01	16 43 06	45A	T T		10	2
Virginia Key	25-Oct-01	16 43 06	45A	SF		12	2

APPENDIX B

Marine Algae and Invertebrates

Marine Algae and Invertebrates

Scientific Name	Common Name
ALGAE	
Udotea spp.	Green algae
Jania spp.	Red algae
Caulerpa sertolarioides	Green algae
Halimeda spp.	Green algae
Penicillus spp.	Green algae
Laurencia spp.	Red algae
Dictyota spp.	Brown algae
Chaetomorpha spp.	Green algae
SPONGES	
Ircinia spp.	Sponge
Cliona spp.	Encrusting sponge
Niphates spp.	Vase sponge
CORAL	
Millepora spp.	Fire coral

APPENDIX C

Photographs

Dense *Thalassia testudinum* near Island E

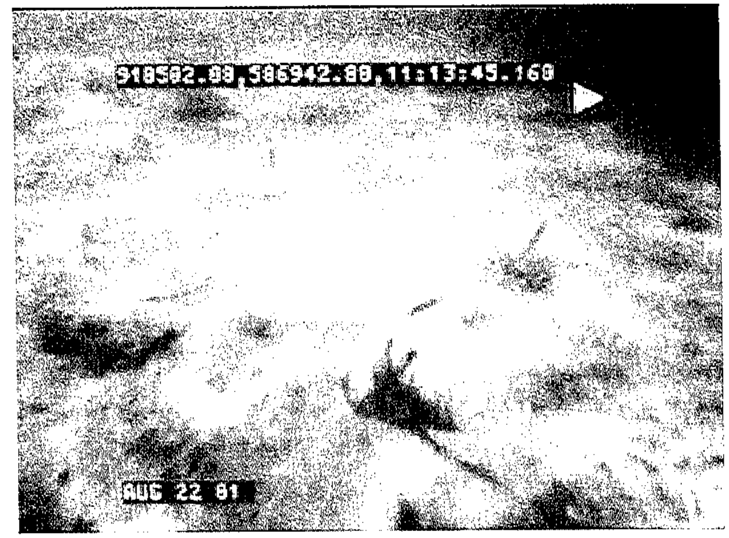
Scattered algae in marina area

Medium density *Thalassia testudinum*

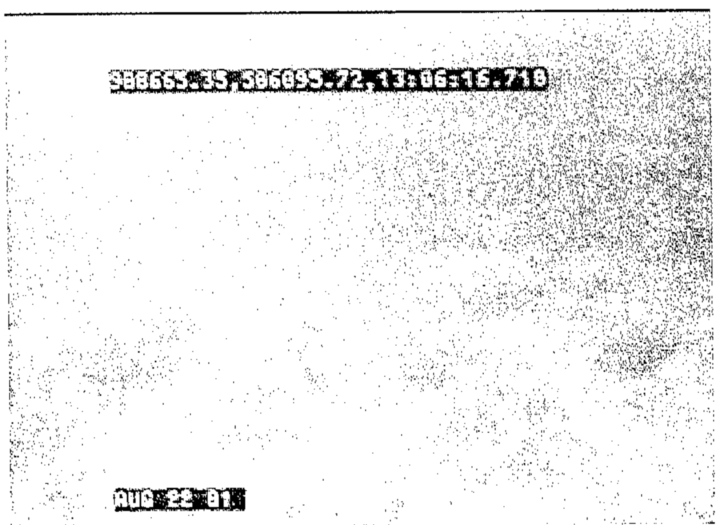
Halodule wrightii adjacent to Virginia Key

Dinner Key/Virginia Key

Halodule decipiens in Marina area



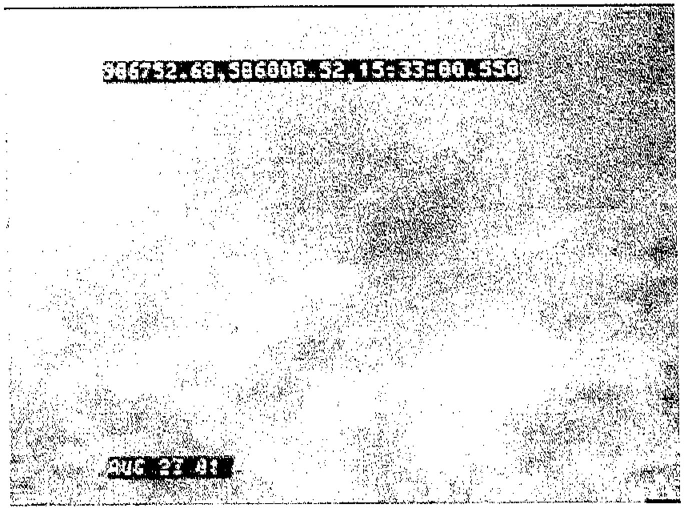
Sand bottom with scattered algae



Scattered rubble with attached algae in marina area

Sponges attached to rubble along marina channel

Dinner Key/ Virginia Key



Scattered algae and upside down jellyfish in marina area


Syringodium filiforme off Virginia Key


Dense *Thalassia testudinum* off Virginia Key


Mixed *Thalassia testudinum* and *Halodule wrightii*

Dinner Key/ Virginia Key